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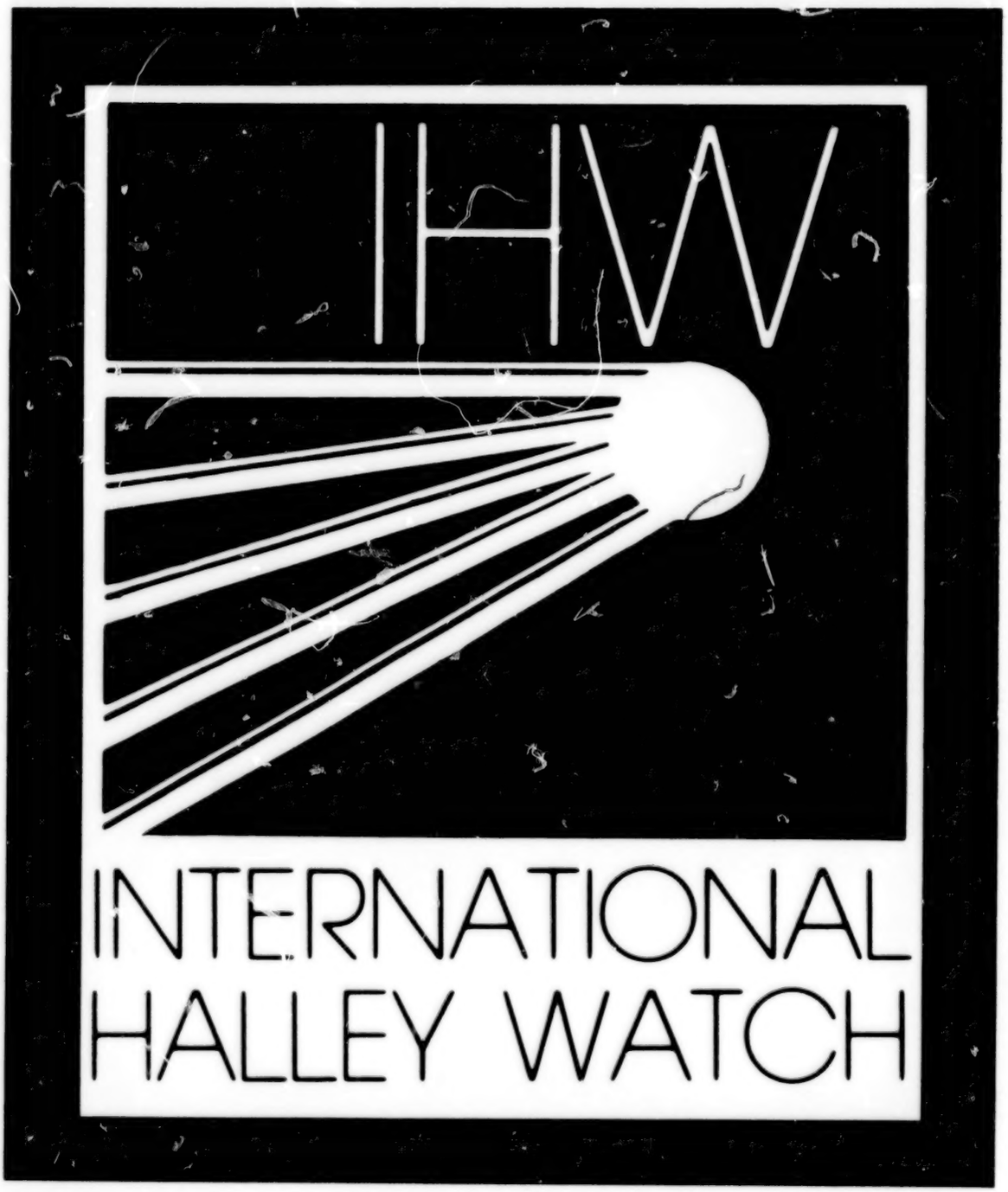
Newsletter No. 4

January 1, 1984



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THE INTERNATIONAL HALLEY WATCH NEWSLETTER

Issue No. 4 January 1, 1984

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IHW Newsletter Editor: Stephen J. Edberg

EDITORIAL

This is the fourth IHW Newsletter. Future issues will appear on an irregular or quarterly basis. Our hope is to maintain open lines of communication between the IHW Lead Center, discipline specialists, observers, flight projects, and other interested readers. We invite short contributions on scientific, instrumental, or social aspects of preparations for the Halley apparition. Please submit items of interest to the editor at the address below.

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Sir:

I was intrigued by the article (Anon., 1983) on the pronunciation of the surname of Edmond Halley, alias Edmundus Halleius. If his name had been Hall or Smalley, we would have had little doubt as to the pronunciation. Whalley might have been less certain, but it is curious that Halley gives us so much difficulty.

In addition to the three usual versions, Halley (to rhyme with tally), Hayley, and Hawley, the recent literature mentions what are apparently (but perhaps only apparently) two additional possibilities. Halliday (1983) (will future generations speculate on the pronunciation of his name?) suggests that it may have rhymed with "trolley" or presumably "holly," while Hughes (1983) suggests "poorly."

In an effort to understand where these versions came from, I asked a number of people to read aloud the sentences "Mr. Hawley has a holly tree" and "Mr. Hawley is proper poorly."

My findings: English people pronounce "Hawley" and "holly" very differently; Americans retain a small but discernible distinction; and Canadians hardly distinguish the sounds at all! Thus, Ian Halliday (a Canadian) was possibly not intending to introduce a fourth pronunciation. When it came to the second sentence, I found that it was the English who speak poorly. I could barely distinguish between their "Hawley" and "poorly." (I hasten to add that only the English knew what the sentence meant--they all understood that Mr. Hawley was very ill). I conclude that Canadian Halliday ("trolley") and Englishman Hughes ("poorly") were both referring to the "Hawley" version.

I also asked my subjects to read the interesting sentences: "Merry Christmas! Will you marry me, Mary?" and "What colo(u)r is your collar?" but the results of that investigation will have to be written up elsewhere.

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References

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Halliday, I., 1983, J. Roy. Astron. Soc. Canada, 77, 63.
Hughes, D. W., 1983, Nature, 304, 119.

Editor's Note: In a follow-up note Dr. Tatum says:

"... it is fun to go through the alphabet saying things like:

All - Alley	Call - Calley
Ball - Balley	etc ...

A fairly consistent pattern emerges, but there are some exceptions, e.g.

Small - Smalley	Wall - Walley"

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CORRECTIONS

R. G. Warren points out inconsistencies in the designation of Comet Forbes used in the discussion of Comet Crommelin on pages 7 and 10 of Newsletter 3. According to Brian Marsden's Catalog of Cometary Orbits (S.A.O. 1982 and Enslow 1983) Comet P/Crommelin = Comet Forbes 1928 III.

It has also been pointed out that the G. Forbes given on pages 13 and 15 of Newsletter 3 was not the "discoverer" of Comet Forbes 1928 III. That honor belongs to A. Forbes, son of G. Forbes. Additional details on the history of P/Crommelin will be found in the next article.

THE ORBIT OF PERIODIC COMET CROMMELIN

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The first definite observations of P/Crommelin are those by Jean-Louis Pons at the Marseilles Observatory during a four-day interval in February 1818. As was so often the case with Pons' comet discoveries, no observations were made elsewhere, and his own very crude observations were scarcely adequate for an orbit determination. In fact, more than thirty years elapsed before anyone seems to have attempted to calculate an orbit, at which time the English astronomer, Norman Pogson, suggested that Pons' comet might be identical with the comet of 1772, by then generally suspected to have been P/Biela. Twenty more years elapsed, after which time his compatriot John Russell Hind disproved Pogson's hypothesis. Hind's paper was in fact published in 1872, barely one year before P/Crommelin was rediscovered, again at Marseilles, by Jerome Coggia, and independently the following night by Friedrich August Theodor Winnecke, then director of the Strasbourg Observatory. Immediately after this November 1873 rediscovery, the director of the Vienna Observatory, Edmund Weiss, was proposing that the 1818 and 1873 comets were identical and discussing the possibilities that the comet had made just one revolution in the interim or perhaps as many as eight revolutions (i.e., the revolution period was either 56.0 or 7.0 years). In 1873 the accurate positions measured of the comet spanned just five days (because the comet was only 0.22 AU from the earth at the last observation and rapidly moving into inferior conjunction), clearly an improvement over 1818 but far from sufficient to determine other than a parabolic orbit. In a paper three years later Weiss was suggesting that the comet had made either three or nine revolutions between 1818 and 1873 (periods 19.0 or 6.2 years), and he tended to favor the latter. By far the most complete nineteenth-century treatment of the problem was that by Leopold Schulhof, a Hungarian-born astronomer who had been working at the Vienna Observatory at the time of the 1873 discovery and who later moved to Paris. In an extensive series of papers published in 1886 and 1887 Schulhof attempted to consider the consequences of the planetary perturbations on the various possibilities for the number of intervening revolutions. He was immediately able to demonstrate the impossibility of eight or more revolutions and felt that periods close to Jupiter's own period (i.e., four or

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five revolutions) were also unlikely because of the large perturbations that would ensue. On the whole, he tended to favor the three-revolution solution and prepared a prediction for the supposed 1892 return. His dismissal of the correct two-revolution solution (period 28 years) seems to have been on the grounds that the perturbations were not large enough to account for the apparent differences between the orbital elements deduced in 1818 and 1873. Schulhof felt that the one-revolution solution was still viable but not if one supposed that the comet was also identical to one observed in January 1457. In 1884 Giovanni Celoria had published an orbit for the 1457 comet on the basis of careful charts drawn by Paolo Dal Pozzo Toscanelli in Florence. Schulhof also considered a scenario in which the 1457 comet had broken up and returned as separate objects in 1818 and 1873.

There the subject rested until November 1928, when the comet was again accidentally discovered by South African architect and amateur astronomer Alexander Forbes Irving Forbes. Within days, Andrew Claude de las Cherois Crommelin--well known for his work in connection with the 1910 return of P/Halley--was announcing at a meeting of the British Astronomical Association his opinion that the 1928 comet was identical to that of 1873. After studying Schulhof's work, Crommelin very soon afterward referred to the comet as P/Pons-Coggia-Winnecke-Forbes and remarked that a 27.7-year period would also fit Toscanelli's observations in 1457. Charles H. Smiley, then at the University of Illinois, also quickly noted the likelihood of identity of the 1818, 1873 and 1928 comets but does not seem to have considered what the revolution period might have been. On measuring his fourth positional observation of Forbes' comet over a span of ten days, Harry E. Wood in Johannesburg directly determined the revolution period as around 26 years and independently proposed identity with the 1818 and 1873 comets and a true period of 27.7 years. Thanks to the continuing Johannesburg observations, a previously unconfirmed discovery of the comet in Japan, and a prediscovery photograph in Switzerland, the total span covered by the observations in 1928 was almost two months, and Crommelin confirmed that the 27.7-year period had to be the correct one. He then reworked in detail the perturbations the comet would have experienced during 1818-1928 and somewhat less rigorously demonstrated that the 1457 comet was the same object. He predicted the next perihelion date as 1956 October 8 and recognized that the comet would have been impossibly placed for observation at its return in May 1901 and that it was not really surprising that it had escaped detection in September 1845. In a 1934 paper Crommelin considered that a bright comet observed by Wilhelm Schickard in Tubingen in January and February 1625 may have been the same object, but he dismissed further candidates recorded in 1708 and 1569. When the three-name limit for comets was adopted in 1939 (the year of Crommelin's death), the appellation P/Pons-Coggia-Winnecke-Forbes became unacceptable, and in 1948 the International Astronomical Union appropriately rectified matters by formally renaming the comet P/Crommelin. A revised prediction for the 1956 return by John Guy Porter and Michael P. Candy in the Handbook of the British Astronomical Association indicated a perihelion date 11 days later than Crommelin had specified. After several unsuccessful searches, P/Crommelin was independently recovered visually by Ludmilla Pajdusakova at the Skalnate Pleso Observatory on September 29 and photographically by Michael J. Hendrie in eastern England two hours later. The observed perihelion date turned out to be six days later than the prediction by Porter and Candy, 17 days later than that by Crommelin. As in 1928 the total span of observations in 1956 was two months.

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My own involvement with P/Crommelin occurred in 1972 in the course of my investigations on the effects of nongravitational forces on the motions of comets. By then it had become clear that the influence of these forces--presumably due, following the 1950 suggestion by Fred L. Whipple, to the comet's reaction to the loss of particulate material following the vaporization of some of the ice that contained it--was detectable in the motions of most comets that had been observed at three or more perihelion passages. There were a few exceptions, notably P/Neujmin 1 and P/Arend-Rigaux. These two comets are remarkable for their generally asteroidal appearance, and I had in fact predicted that nongravitational effects would not be detectable even though the observations of the former comet covered an interval of more than half a century; the latter comet was not discovered until 1951, but a recent computation using observations at the five perihelion passages from discovery through 1978 still shows no evidence for nongravitational effects. P/Crommelin was a most unexpected exception to the rule. With its rather small perihelion distance (0.75 AU), its curious photometric behavior and the errors in the 1956 predictions, I expected to find quite large nongravitational effects. Instead, I discovered that it was possible to fit the observations in 1873, 1928 and 1956 with a purely gravitational solution--the longest span of time for which the motion of any known comet can be so represented! It is true that there was an indication that the resulting calculated perihelion time for 1818 might have to be adjusted by as much as -0.2 day, but this would have been a remarkably small correction for an extrapolation over half a century, and in any case Pons' observations were far too rough to take this adjustment seriously. I experienced much more of a problem with the supposed observations in the seventeenth and fifteenth centuries. On running my gravitational solution back into the past I derived perihelion dates in October 1624 and February 1456, or three and eleven months, respectively, earlier than they should have been. This was not in itself damning evidence against the supposed identifications, for it was reasonable to suppose that nongravitational effects could certainly perhaps have a significant effect on the comet's motion over an interval of several centuries. The 1818 observations had suggested a possible very slight secular acceleration (i.e., that the comet had a negative transverse nongravitational component). By exaggerating this negative transverse component to an amount comparable to that observed for the most nongravitationally-affected comets, I confirmed that perihelion passage might have occurred in September 1624 and November 1455. Introduction instead of a secular deceleration gave, as one might anticipate, later perihelion dates in former centuries, but the dependence of perihelion dates on nongravitational parameters is not linear, and a comparable positive transverse component gave perihelion dates much closer to those derived in the absence of nongravitational effects. There seems to be no simple means to produce perihelion dates of P/Crommelin nearer to the times of the Schickard and Toscanelli observations than November 1624 and March 1456, so unless the nongravitational forces were subject to variations of an extremely bizarre nature, these ancient identifications must be considered invalid.

The 1983 recovery independently by Lubos Kohoutek on August 9-10 at Calar Alto and by Sue Wyckoff and Peter A. Wehinger at Kitt Peak on August 13 confirms that the nongravitational forces on P/Crommelin continue to be very small, the indicated correction of -0.04 day to my gravitational perihelion time of 1984 February 20.19 again showing that the comet possibly has a very slightly negative transverse nongravitational component. The surprise was that the comet should already be detectable more than six months before perihelion at a helio-

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centric distance of almost 3 AU. Absence of nongravitational effects can indicate (as with P/Neujmin 1 and P/Arend-Rigaux) a comet that is essentially inert. If only the more readily detectable transverse effect is considered, absence can also indicate that a comet's axis of rotation is essentially in the plane of its orbit; that would presumably be only a temporary situation, however, and in time one would expect the transverse component to reappear. Irrespective of what one makes of the proposed observations in the seventeenth and fifteenth centuries, it is clear that the motion of P/Crommelin holds the record for gravitational stability during the nineteenth and twentieth centuries! The comet ought therefore to be essentially inert, and the recovery observations suggest that it is. Since all our previous experience with P/Crommelin has been only when it was within 1.1 AU of the sun (and generally within 0.9 AU), when any comet worthy of the name is bound to show some cometary activity, and since what crude photometry exists suggests considerable variation of brightness with heliocentric distance, there was no way to predict just how bright the nucleus of P/Crommelin might be. An outburst at the time of recovery was perhaps unlikely; the persistent absence of nongravitational effects might indeed suggest a relatively large and prominent true nucleus at large heliocentric distances; and to suppose an asteroidal law with absolute magnitude 16.0 (and phase coefficient 0.03 mag/deg) would therefore not be unreasonable for the nuclear photographic magnitude. This formula yields apparent magnitudes of 17.4 at the time of Pons' observations, and fading from magnitude 16.1 to 16.5 during the brief 1873 apparition. During the 1928 and 1956 apparitions the magnitude would have ranged from near 17 at the beginning to fainter than 18 at the end; specifically, the calculated nuclear magnitude of 17.2 during the first half of October 1956 compares appropriately with the observed value of 14 derived by Elizabeth Roemer for the nuclear condensation on exposures with the 0.6 m reflector at the Yerkes Observatory. One can conclude that P/Crommelin is not likely to be fainter than magnitude 17.5 during the proposed IHW observing campaign of 1984 March 25-31. The nuclear brightness can be calculated to be only 0.2 magnitude brighter at perihelion, although the comet's total brightness must then obviously be very considerably greater than it will be during the campaign.

PLASMA AND DUST TAIL ORIENTATIONS FOR HALLEY'S COMET IN 1985-1986

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In 1910, Halley's Comet displayed both a dust and a plasma tail but a major complication in their analysis was a frequent plane-of-sky superposition caused by the shallow angle between the line of sight to the comet and the orbit plane. An examination of the photographs in Bobrovnikoff's (1931) monograph shows that the plasma tail was often weak or invisible as it was hidden by the stronger dust tail in many unfiltered photographs. Also, as Sekanina (1982) has pointed out, the low cometocentric latitude of the earth all but eliminated any visibility of the dust tail's curvature, thus rendering impossible a Finson-Probstein analysis of the 1910 data.

The Large-Scale Phenomena Discipline Specialist Team considers it a "given"

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that Halley's Comet will have strong plasma and dust tails in 1985-1986. Before developing detailed plans concerning optimum filter/film combinations, however, it was considered necessary to examine the geometrical circumstances that will apply in 1985-1986, and particularly, the possibility that the unfavorable tail geometry of 1910 will be repeated.

The following procedure was used. The most detailed analysis of any cometary dust tail is generally agreed to be that performed for Comet Arend-Roland by Finson and Probstein (1968). In the absence of any useable 1910 dust data, the simplest procedure in modelling 1985-1986 was to take the orbit plane syndynes derived for Comet Arend-Roland on 1957 April 27 (cf. Finson and Probstein, 1968) and assume that the Halley dust syndynes will be similar. No attempt was made to model the temporal evolution (length or orientation) of the dust tail, but an artificial shift procedure was developed which makes the syndynes either more radial or more curved (in the orbit plane) as the user sees fit, the same shift applying to all dates. The plasma tail orientation on the sky plane was assumed to be that of a tail lying in the orbit plane and lagging the prolonged radius vector by 5°. As in the case of the dust tail, no attempt was made to include temporal evolution of plasma-tail linear length, and 0.1 AU was assumed for all times. The purpose of the exercise was not to derive angular tail lengths as functions of time, but rather, relative tail orientations on the sky with time.

The accompanying figures are Calcomp plots showing plane-of-sky tail orientations. The curves are dust syndynes ($1 - \upsilon = 0.1$, 0.2, and 0.3 for Comet Arend-Roland) and the straight structure is the plasma tail. It was found that for reasonable shifts of the syndyne curves, the relative tail orientations were not dramatically different from the unshifted case. In the plots, ϕ is the direction of the prolonged radius vector, ψ denotes the minus orbital velocity vector of the comet, north is up, east is left, and 5°/inch is the approximate angular scale.

The major conclusions to be drawn are that in late 1985, a 1910-type situation will exist with tail superposition being a frequent problem. Hence, narrowband filtering will probably be necessary for effective plasma tail imaging at this time. However, for 1986 March-April, the two tails should be widely separated and well suited to study by wideband (unfiltered) photography. The appearance of these well-separated tails should be rather similar to the appearances of Comets Mrkos 1957d and West 1975n. Filter choices for 1985-1986 are currently under study by the L-SP Discipline Specialist Team and will be discussed in detail both in future newsletters and in upcoming L-SP circulars.

References

Bobrovnikoff, N. T., 1931, Publications of the Lick Observatory, Univ. of Calif. Press, Vol 17, Pt. II, p. 305.

Finson, M. L., and Probstein, R. F., 1968, Astrophys. J., 154, 353.

Sekanina, Z., 1982, in Advances in Space Research, Vol. 2, No. 12, (Oxford, Pergamon Press), p. 121.

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Figure 1. Predicted tail orientations for P/Halley on 1985 December 11.

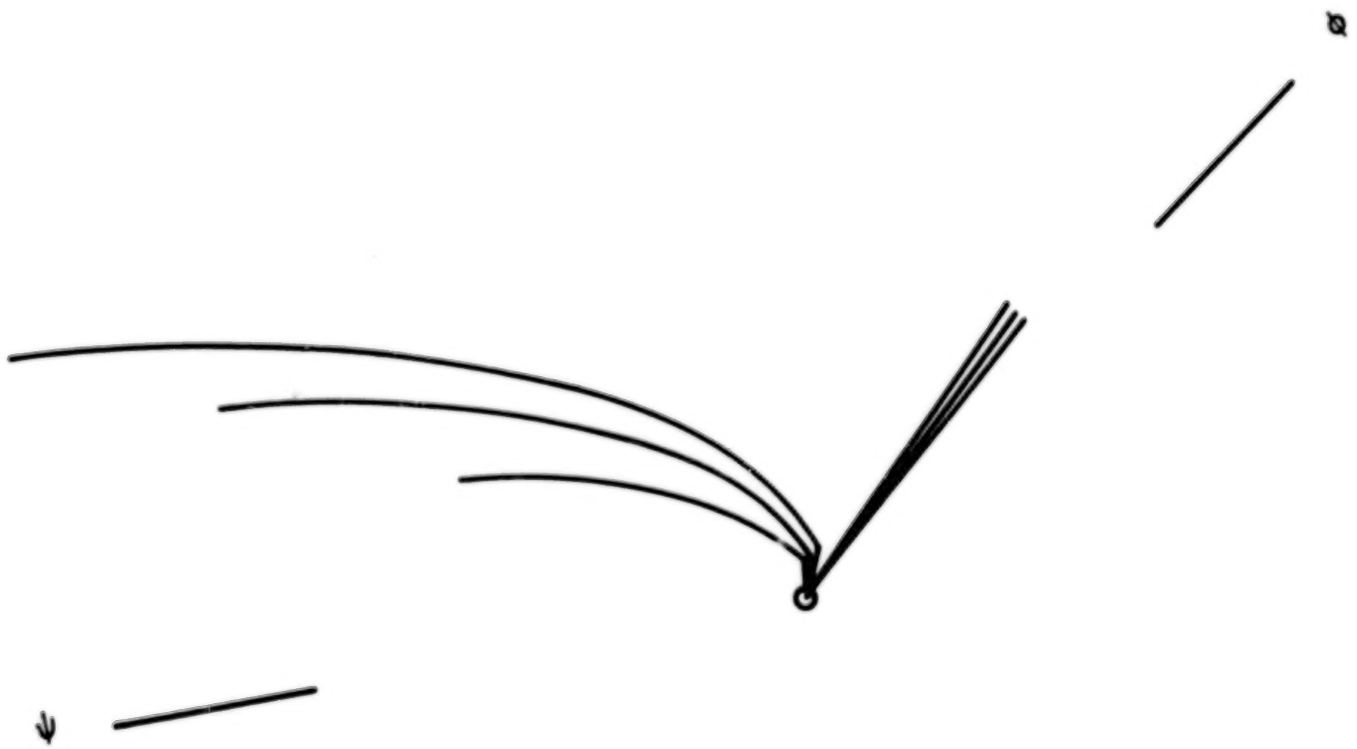

Figure 2. Predicted tail orientations for P/Halley on 1986 April 10.

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OPPORTUNITIES FOR HALLEY OBSERVATIONS USING NASA AIRBORNE OBSERVATORIES

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One of the principal roles of the International Halley Watch is to advocate observations of Halley's Comet by all of the world's major astronomical facilities. In this connection, we have contacted the users committee of the NASA airborne observing program (C141 and Lear Jet) to discuss the prospects for observations of the comet. Observations of the comet from the air offer clear advantages to observations from the ground in a number of very important areas. Searches for parent molecules, many of which are found also in the terrestrial atmosphere, should be more sensitive from the air. Several important spectral features of ices and silicates also exist in the regions of the spectrum obscured by the earth's atmosphere. Finally, at the time of Halley, airborne observations will be the only source of information about the intermediate and far IR spectrum of the comet. For all of these reasons, a significant use of the NASA airborne program for Halley observations seems to be highly desirable.

The airborne program is expensive, and its use for observations of comets must be justified in terms of both community support and proposal pressure. A significant program on Halley, which may require new instrumentation and, possibly, a decision to move the base of operations to the southern hemisphere, also require a long preparation lead time. Specific observing requests are due at NASA by February 1984 for the time period October 1984 - October 1985. Proposals for this time would obviously include early observations of Halley as well as any observations in the nature of a trial run. Observing proposals for the most crucial time period for Halley, October 1985 - October 1986 must be made by February 1985. Since this gives only about one year for preparation of proposals, it is essential to start to identify and organize the people who wish to participate.

If you are interested in using the airborne observatories or have specific ideas for projects which would make good use of the airborne capability, we would appreciate hearing of your interest. We note that collaborations with the present users of the airborne facilities are both possible and strongly encouraged. For further information, contact either author. (A general discussion of flight plans for Halley during 1985-86 will appear in a future newsletter. - Editor)

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THE FACILITIES OF THE CERRO TOLOLO INTER-AMERICAN OBSERVATORY IN CHILE

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The Cerro Tololo Inter-American Observatory (CTIO) is operated by the Association of Universities for Research in Astronomy (AURA) under contract with the National Science Foundation, for the benefit of the scientific community in general. The observational facilities consist of eight optical telescopes of modern design and an extensive complement of auxiliary instrumentation that is largely oriented toward stellar and extragalactic astronomy. In addition, computer facilities and measuring equipment are provided at the observatory or its headquarters. Telescope time is awarded competitively on the basis of scientific merit and the need for a southern hemisphere facility. All observing proposals from prospective visitors are reviewed by the CTIO Telescope Allocation Committee (TAC) comprised of about eight astronomers not on the AURA staff. A CTIO staff representative on TAC is responsible for administering the review process, for converting TAC's decisions into a workable telescope schedule, and for corresponding with the applicants.

CTIO's headquarters is located in La Serena, Chile, a 430 year old coastal city of ~ 100,000 inhabitants 480 km (300 miles) along the Pan American Highway north of Santiago, Chile. The observational facilities are located on Cerro Tololo, 80 km east-southwest of La Serena, at an elevation of 2,210 m (7250 ft). The geographic coordinates of CTIO (astronomical longitude and latitude at the Curtis-Schmidt telescope) are, respectively:

λ W 70°48'52".7 ± 2".0 (W $4^h43^m15^s.5$),
ϕ S 30°09'55".5 ± 1".4

CTIO was located in Chile after an extensive search for good astronomical observing sites in the southern hemisphere. Recognition by the Chilean government as an international organization and an agreement with the University of Chile facilitate the operation of CTIO within the Republic of Chile.

CTIO's organization includes a Scientific Division responsible for research and the development of telescopes and instruments. Staff scientists with various specialties are available to visiting astronomers for consultation on how to make the most effective use of the available instrumentation. In addition to normal administrative and housekeeping tasks, an Administrative Division is responsible for helping visitors travel to, from, and within Chile. This division maintains special offices in Tucson, Arizona, and in Santiago, Chile, in order to provide visitors with more effective assistance. A third and final observatory division, Engineering and Technical Services, provides the expertise required to solve major instrumental problems. A Visitor Support Department in

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the ETS Division provides the routine day-to-day scientific assistance observers require.

Application for Use of CTIO Facilities

The equipment and facilities of the Cerro Tololo Inter-American Observatory are constructed and maintained for use of the scientific community in general. Available observing time on Cerro Tololo telescopes is shared by visitors and staff. Visitors are assigned at least 60% of the time. By agreement between AURA and the University of Chile, up to 10% of available observing time may be assigned to observers from the Universidad de Chile who present meritorious programs. Because of the Inter-American nature of the Observatory, preference is given to astronomers from the western hemisphere. Also, among proposed observational programs for CTIO that are of equal scientific merit, preference will be given to those programs by observers from U.S. and Latin American institutes. Similarly, preference will be given to programs for which observations from the southern hemisphere are particularly advantageous and that can not be readily carried out elsewhere. Final responsibility of all allocation of telescope time shall be the Director's.

Telescope assignments are made for the following periods:

SEASON	PRINCIPAL OBJECT	DATE PROPOSAL DUE
Feb 1 - Jul 31	Carina, Centaurus, Galactic Center	Sep 30
Aug 1 - Jan 31	Magellanic Clouds, South Galactic Pole	Mar 31

Because of the large number of requests that must be handled, all prospective observers are requested to use standard request forms and to be as succinct as possible, limiting their requests to the relevant information that may be required by referees to review and comment on the merits of an observing proposal.

Requests for observing time on all CTIO telescopes and for the use of CTIO's analytical equipment are to be submitted using only the standard Observing Time Request Form available from and submitted to:

The Director
Cerro Tololo Inter-American Observatory
Casilla 603
La Serena, Chile

Proposal Submission Deadlines

Requests must ARRIVE at CTIO by September 30 or March 31, for the corresponding telescope assignment periods. Late requests are usually very difficult to satisfy and will be considered at the discretion of the Director. Please allow at least two weeks for airmail delivery from the U.S.

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SUMMARY OF AVAILABLE TELESCOPES AND INSTRUMENTATION AT CTIO

Aperture m / in	Focus f/# / type	Scale "/mm	Mounting	Tube On ? Side of Polar Axis	Cross Tube Over Polar Axis?	Finder diam-cm / field-°	Computer Contrld. Drive Motions?	Instruments
4.0 158	2.66 Prime	18.6	Horseshoe				Yes	Pg. and image-tube cameras, IR photometer, CCD camera
	7.76 R-C	6.56						Photometer, spectrograph, echelle spectrograph, camera, vidicon, TV guider
	30 IR	1.71						Infrared photometer
1.5 60	7.5 R-C	18.06	Asymmetry off axis	E	Difficult	15.2	Yes	Offset guiders, spectrograph, Fabry-Perot, camera, vidicon, scanner, TV guider
	13.5 Casse-grain	10.03						Offset guiders, photometers, 2-prism spectrograph, Fabry-Perot, camera, vidicon, TV guider
	30 IR	4.55						IR photometer
	31.2 Coude	4.52						Coude spectrograph
1.0 40 (Yale)	10 R-C	19.5	Asymm. off axis	E	Moderately Easy	15.2 1	Planned	Offset guiders, photometers, IT spectrograph, 2-prism spectrograph, camera
0.9 36	13.5 Casse-grain	16.5	Asymm. off axis	E	No	15.2 1	Planned	Offset guiders, photometers, spectrograph, 2-prism spectrograph scanner, Fabry-Perot
0.6/0.9 24/36 (Michigan)	3.5 Schmidt	96.63	English		Easy	12.7 2.25	No	Direct photograph with or without 1.5, 4, 6, or 10° objective prisms
0.6 24 (Lowell)	13.5 Casse-grain	25.0	Asymm. off axis	W	Easy	10.2 1	No	Light offset guider, photometers, 2-prism spectrograph
0.4 16	18.75 Casse-grain	27.1	Asymm. off axis	W	Easy	12.7 2	No	Photometers, 2-prism spectrograph, light offset guider

//

SUMMARY OF ANGULAR SPEEDS OF CTIO TELESCOPES

TELESCOPE		SLEW (arc-degrees/sec-time)	SET (arc sec/sec-time)	GUIDE (arc sec/sec-time)	Digital or Conventional Drive Oscillator
4.0 m	RA	0.5	60	1	Digital
	DEC	0.75	60	1	Digital
1.5 m	RA	1.75	2.7 - 45.5* ~ 85.	0.001 - 10.0* 10.0	Digital
	DEC	1.75	1.6 - 44.7* ~ 85.	0.004 - 9.7* 10.0	Digital
1.0 m	RA	3	116	0.96	Conv.
	DEC	3	110	1.08	None
0.9 m	RA	3	116	0.96	Conv.
	DEC	3	110	1.08	None
Schmidt	RA	Manual	3172 or 393†	14.00 or 1.32†	Both
	DEC	Manual	3158 or 386†	11.51 or 1.46†	None
0.6 m	RA	4	188	3 - 180	Conv.
	DEC	4	188	3 - 180	None
0.4 m # 1	Ra	6	90	3	Conv.
	DEC	6	90	3	None

* Variable in discrete steps only dependent on selected track speeds.
† Fixed rates selected by a two-position switch on the hand paddles.

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RAPID NOTIFICATION OF COMET DISCOVERIES AND RECOVERIES

The Smithsonian Astrophysical Observatory, on behalf of the International Astronomical Union, publishes the IAU Circulars and IAU Telegrams. The circulars announce the discovery of new comets and give follow-up information including further observation reports, orbital elements, and ephemerides as this information becomes available. The circulars also make rapid reports on the discoveries of novae, supernovae, unusual minor planets, and other items of urgent interest including reports on new planetary satellites, planetary occultations, and optical identifications of sources discovered in other spectral regions.

A selection from several categories of IAU Telegram service allows astronomers to receive the most urgent information on new discoveries. A subscription to the circulars is required for a subscription to the telegrams.

For more information on these services contact the

Central Bureau for Astronomical Telegrams
Smithsonian Astrophysical Observatory
60 Garden Street
Cambridge, MA 02138, USA

METEOR OBSERVATIONS AND THE IHW

S. J. Edberg
International Halley Watch
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109
USA

The International Halley Watch has been organized to advocate, coordinate, standardize, and archive observations of physical phenomena related to Halley's Comet. Observations of the two meteor streams associated with Halley, the η Aquarids and the Orionids, fall within this responsibility. While discipline specialists have been selected for other areas of astronomical technique, insufficient funds were available to support a discipline specialist to coordinate efforts in the study of these meteor streams.

While our contacts may be somewhat less formal, it is still our hope that meteor astronomers will contribute their observations to the IHW archives for publication with other types of comet observations. I am serving as a point of contact for submissions of meteor data, but I am not acting as a discipline specialist in this area. I encourage meteor astronomers to contact me if I can assist them in any way. Halley Meteor Days have been declared for May 2 - 6 and October 20 - 24 through 1987. Amateur observers are also being encouraged to contribute their meteor observations to widen the data base.

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ASTROMETRY

Summary

At this writing, we have 151 active members from 38 countries within our observing network. In addition, another 37 people have asked to be kept informed of our activities. Plans for our Astrometry Network meeting at the European Southern Observatory Headquarters in Munich, FRG (June 18-19, 1984), are proceeding nicely, and the work on the special Halley star catalog is on schedule. An improved set of computer software has been successfully implemented at the orbit determination center at JPL. A questionnaire concerning data communication channels was sent to each active observer in the Astrometry Network.

Astrometric Observations of Comet Crommelin Requested

If at all possible, each active member of our Astrometry Network should provide at least a few astrometric observations of Comet Crommelin during February and March of 1984. A star catalog with selected SAO catalog stars along the comet's path from mid-February to early April 1984 has been sent to all active observers for use in their data reductions. This catalog, put together by Dr. R. S. Harrington, is in the same format as the forthcoming star catalogs for Comets Halley and Giacobini-Zinner. (Observers who wish to use this catalog on either punch cards or magnetic tape should send their requests [along with a box of cards or a tape] directly to Dr. Harrington.) A general description of astrometric data reductions (by Dr. Marsden) and a Fortran computer program for data reduction (by Dr. Harrington) were also included with the star catalog. The purpose of the observations of Comet Crommelin is to exercise the entire International Halley Watch prior to the observation of Comets Halley and Giacobini-Zinner. For the Astrometry Network, one of the most important results of this Comet Crommelin "dry run" will be to determine how many observers are willing to provide the important astrometric data and to test the communications channels between the observers and the orbit determination center at the Jet Propulsion Laboratory. Observers are requested to send their data directly to both D. K. Yeomans at JPL and to B. G. Marsden at the Central Bureau of Astronomical Telegrams. Those who find it more convenient to send their data directly to R. M. West at ESO should do so, and these observations will be forwarded immediately. Observation reports should have the time of the observation (UTC), the right ascension and declination (1950.0), the observer, and the observatory. Supplemental information might include the comet's total magnitude (m_1), nuclear magnitude (m_2), coma diameter, tail length, and tail position angle (measured east from north). Observations may be communicated by telegram, TELEX/TWX, or airmail. If a more suitable method of communicating observations is not available, telephone messages can be used as well.

Astrometry Network Meeting June 18-19, 1984

All members of our Astrometry Network have been invited to a workshop meeting at the Headquarters of the European Southern Observatory in Munich, FRG on June 18-19, 1984. Our host for this meeting is Dr. R. M. West. This workshop will consist of a number of invited papers on the practical aspects of astrometry for comets and the conference proceedings will serve as a guide for making

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astrometric observations and reducing these data for use in the orbit determination process. One of the topics of discussion at this meeting will be the problems that become apparent as a result of the Comet Crommelin "dry run" in February-March 1984. People planning to attend this meeting should note that it is scheduled just after the I.A.U. Colloquium No. 83 "Dynamics of Comets: Their Origin and Evolution" (June 11-15, 1984 in Rome, Italy) and just prior to the COSPAR meeting in Graz, Austria (June 25-July 7, 1984).

Progress On The Comet Halley Star Catalog

Dr. Arnold Klemola of Lick Observatory informs us that all 18 plates have been taken for the Comet Halley reference star catalog. To date, 12 of these plates have been measured and reduced for equatorial coordinates. The measurements and reductions for the remaining 6 plates are currently under way. Star catalog coverage of the comet's path from mid-February through March 1986 will be provided by a transit circle survey by the U.S. Naval Observatory. This survey is currently under way.

Progress Of Software Development At Orbit Determination Center

The computer software used to process astrometric observations and to make orbit determination solutions has been greatly improved. Incoming observation times in UTC are reduced to ephermeris time, the observatory's coordinates are assigned and the right ascension and declination are corrected for the small effects of elliptic aberration. Once tested, the observations are stored in reverse chronological order on the master data file for use by the orbit determination program. This latter program takes into account the comet's nongravitational perturbations, as well as the planetary perturbations at each time step. The local error allowed at each time step can be input and the time steps of the numerical integration vary to limit the local error to the input value. The partial derivatives of the observables are numerically integrated along with the comet's equations of motion. To be consistent with the reference frame used by the various flight projects to Comets Halley and Giacobini-Zinner, the comets' equations of motion also include general relativistic effects by means of the parameterized space-time metric of the Eddington-Robertson-Schiff formalism. Currently, this program uses a batch processed, weighted least squares technique for the orbit determination.

D. K. Yeomans
R. M. West
R. S. Harrington
B. G. Marsden

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INFRARED SPECTROSCOPY

Introduction

While infrared photometry of comets is well developed, cometary infrared spectroscopy is in a much more embryonic state. Recent instrumental progress indicates that significant opportunities for IR spectroscopy of Comet Halley, and other comets, now exist. We hope that such observations will be stimulated and encouraged in the Halley Watch period.

Circular Variable Filter (CVF) Observations

These devices, incorporating interference filters in the shape of wedges for continuous, variable transmission, have seen widespread applications in infrared astronomy. Their intermediate resolving power (R = 25 - 100) makes them suitable for the study of broad dust and molecular bands.

A particularly important result was the 8 - 14 μm spectrum of Comet Kohoutek, obtained by Merril (1974). This showed the remarkable similarity of the cometary silicate emission and circumstellar and interstellar features. Recently a series of observations using CVF and broad-band techniques have been made to search for H_2O ice (A'Hearn et al., 1981; Campins et al., 1983; Hanner, 1983). These observations show the advantages and limitations of the techniques. The ice band should be identifiable with CVF resolution, but recent comets were so weak that only a few spectral points could be obtained. Hanner (1983) integrated for many hours on the IRTF (3 m) to obtain 3 data points near 3 μm on Comet Cernis. At this time it seems clear that there is interesting structure near 3 μm in comet spectra (where r > 2 AU), probably including the signature of ice, but more data are needed.

The observations of Jewitt et al. (1983) show that much spectroscopic work needs to be done in the 1.5 - 2.4 μm wavelength range. They find spectral features that are <u>not</u> due to H_2O, CH_4, or CO_2 ices, nor to emissions from known gases nor to reflection by known mineral grains. The spectrum of solid ammonia provides the best match to the near infrared; it is nevertheless significantly different from the comet spectra. Kawara et al. (1978) found a featureless spectrum in the 2.8 - 3.6 μm interval of Comet West (1975).

Halley's Comet should be bright enough for a few weeks near perihelion for CVF spectroscopy and we encourage individuals with this equipment to plan such observations. Fifteen observatories have been identified with CVF capability in the infrared net, so we can look forward to solid spectroscopic coverage if the weather and the comet cooperate. Note that ice observations should be made when r > 1.5 AU as the ice grains sublimate within that heliocentric distance.

The 4 - 8 μm region has turned out to be very interesting for interstellar dust studies. Comet observations in this spectral region with airborne instruments should be attempted.

The VEGA spacecraft contain two CVF spectrometers (2.5 - 5 μm, 6 - 12 μm) for spectroscopy of the inner coma. These instruments will be used to search for parent molecules and dust features.

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Multichannel Spectroscopy

A number of spectrometers incorporating multidetector technology are coming on line or are expected to be ready by 1986. They typically incorporate 10 - 30 detectors in grating systems with resolving powers in the R = 50 - 1000 range. Most interest is in the 1 - 5 μm InSb region, although systems are also being developed for longer wavelengths. These instruments seem ideal for comet observations. With a speed increase over a CVF scanning system equal to the number of detectors, they should have just the required gain necessary to get extensive data on comets similar to the recent brighter ones. Seven observatories with such instrumentation have joined the infrared IHW network.

High Resolution Spectroscopy

Observations of comets at resolutions of R > 100 in the infrared are presently rare. A notable result is the 0.9 - 2.5 μm spectrum of Comet West obtained by Johnson et al. (1983). The resolution obtained with a Fourier Transform Spectrometer was $\Delta\nu = 4.6$ cm^{-1}. Strong emissions by C_2 and CN were detected. No absorptions by ices (r ~ 0.65 AU) nor emissions by parent molecules were found.

Since Halley's Comet will not be enormously bright during the 1986 apparition, the highest resolution observations will be limited to the near-perihelion period. However, they should be attempted if at all possible because of the important information that may be gained from such work. For example, the fundamental band of CO at 4.6 μm may be shifted out of the terrestrial CO absorptions in a fast-moving comet. A 0.3 cm^{-1} shift corresponds to 42 kms^{-1}. Fabry-Perot and heterodyne techniques may also be advantageous, especially when specific lines are sought. Nine investigators with advanced, high resolution instruments of the FTS, Fabry-Perot, or heterodyne types have joined the infrared IHW network.

Predictions

In the past year, several predictions of infrared line strengths in comets have been made. We are aware of the following: Crovisier and Encrenaz (1983), Crovisier (1983), Crovisier and LeBourlot (1983), Weaver and Mumma (1983), and Yamamoto (1982).

R. F. Knacke
T. Encrenaz

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LARGE-SCALE PHENOMENA

Since the time of the last newsletter, the Large-Scale Phenomena (L-SP) Discipline Specialist Team has been active in a number of different areas: 1) augmentation of the Halley Network, 2) development of Comet Crommelin trial run plans, 3) absolute intensity calibration of uncalibrated plates using computer image-processing techniques, and 4) determination of plane-of-sky orientations for Comet Halley's dust and plasma tails throughout the 1985-1986 apparition.

L-SP Halley Network

At the present time (December 1), 78 observatories have joined the network, the purpose of which is to obtain frequent wide-field ($\geq 5°$) images in order to permit the effective study of the plasma and dust tails of Halley's Comet. Due to the much greater variability of the plasma tail (~hours for major changes vs. days to weeks for dust tail changes), it is this structure that is being emphasized in the construction of such a large network. Plates with maximum sensitivity in the wavelength range λλ4000-4300, such as IIa-O or equivalent, are optimum for the recording of the CO^+-dominated plasma tail. It is likely at this point in the network's construction that most of the world's major Schmidt telescopes and astrographs are included in the net, and an effort is under way to locate remote island locations with which to fill the remaining gaps in our coverage, all caused by the world's oceans. We are looking for qualified individuals on (or who would be willing to travel at their own expense to) such islands to make observations. It may be possible for the L-SP Discipline

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Specialist Team to supply small (D < 20 cm), commercially available Schmidts when appropriate equipment is lacking. Any suggestions and/or volunteers would be welcome and would receive our full consideration.

Comet Crommelin Trial Run

Observations of this comet in late March 1984 by L-SP net members will be used mostly for testing of network communications, network potential, problem areas, etc. As discussed in articles by Festou and Morris in Newsletter #3, Comet Crommelin is not expected to be a spectacular wide field object. The next L-SP circular, in preparation at the time of this writing, will contain objectives and suggested observations. At the present time only ~20 observatories (~25% of the network) have contacted us and said they will join the Trial Run. In view of the importance of this effort, we urge as many net members as possible to participate in the trial run.

Absolute Intensity Calibrations of Wide-Field Plates

Dan Klinglesmith of the L-SP Team has recently successfully applied both the star profile approach of Agnelli et al. (1979) and the density moment sum technique of Zou et al. (1981) to an uncalibrated IIa-0 plate of M31. The result was an absolute intensity map of M31 which agreed with B magnitude photoelectric scans of the galaxy by de Vaucouleurs. Because the determination of plasma tail brightness changes is a large part of our Halley effort, development of such a technique is very important. The method will be described more fully in upcoming circulars.

Plasma and Dust Tail Orientations

In view of the extremely unfavorable situation in which the plasma and dust tails of Halley's Comet were closely superimposed on the sky plane for most of the 1910 apparition, we have been examining the prospects for 1985-1986. This activity is very important for making decisions about filter/film combinations necessary to separate the two tail systems. The results of the orientation study are presented earlier in this Newsletter in a separate write-up by M. B. Niedner.

J. C. Brandt
M. B. Niedner, Jr.
J. Rahe

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NEAR-NUCLEUS STUDIES

Membership

There are 120 observers in 27 countries at 55 observatories (42 in the

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northern hemisphere, 13 in the southern hemisphere) who have indicated that they will participate in the Near-Nucleus Studies Net (N-NSN) by making high resolution images of Comet Halley. Over 70 others are interested in N-NSN activities, but may not participate. There are 28 telescopes with apertures greater than one meter and only 12 CCD detector arrays (8 northern, 4 southern hemisphere) available. Those members who have not returned the questionnaire indicating their instrumentation are urged to do so soon. Otherwise, the response and interest has been quite good and we encourage anyone else interested in the N-NSN to contact any of the N-NSN discipline specialists.

Trial Run On P/Crommelin

Several members have indicated that they will participate in the modified trial run on March 25-31, 1984. Since an important aspect of the trial run is to test the data taking and reduction capabilities of the net, we strongly encourage <u>all</u> N-NSN members to observe the comet during the trial run period, or even in February when the comet is brighter. By now, all N-NSN members should have received the complete technical note series detailing suggested means of standardization and calibration.

Scientifically, it will be desirable to improve our knowledge of the physical characteristics of P/Crommelin since relatively little is now known. Previous newsletter articles have reviewed the results of existing observations, but as we all know, cometary behavior is usually very difficult to predict. The coordinated efforts of all of the IHW nets may yield very interesting results.

N-NSN Comet Halley Observation Schedule Update

Some results of our study of the 1910 Halley images indicate that it is not possible to be sure that the strongest dust coma features will be observed during the designated IHW days only, and that the spatial resolution needed for effective modelling will be obtained when the comet is within one astronomical unit of the Earth. Also, significant scattered moonlight lowers the apparent feature contrast below an acceptable level. Based on these results, we are recommending that additional high resolution images be taken (at a reduced frequency of 3-4 times per day) during the following intervals:

1985 November 3-22
December 3-18
1986 March 4-18
April 3-19
May 1-10

This added coverage will greatly improve the chances of observing major coma features. We do not want this effort to compromise the intensive coverage during designated IHW days, but if there are interested observers with available telescope time during the extended periods we would like to encourage further observations.

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Filters

Based on the response from N-NSN members, we have ordered 15 sets of 38 mm diameter imaging quality filters in the 8 standard IAU comet bandpasses. These filters will be most effective when used with CCD's since photometric, as well as spatial, data will be obtained.

Filter recommendations for use with photographic emulsions were outlined in the first circular. These readily available filters are effective in eliminating CN and C_2 emissions and increasing continuum feature contrast.

Analysis of High-Resolution Images of Halley From 1910

Significant progress has been achieved in the study of high-resolution images of Comet Halley obtained in 1910. The photographs exposed with the 152 cm reflector at the Mount Wilson Observatory have been digitized and computer processed. The resulting images show a complicated spiral-jet structure. The images, relative photometry of a bright jet of dust particles, and some tentative conclusions are summarized in a paper that has been submitted for publication. Photographs of the comet taken with the Crossley 91 cm reflector at the Lick Observatory, which excellently complement the Mount Wilson Observations, have likewise been digitized and their image processing is being carried out. Also in progress are detailed quantitative studies of the comet's dust emission pattern, which are based on these contrast-enhanced images.

S. Larson
Z. Sekanina
J. Rahe

PHOTOMETRIC STANDARD STARS

As we have already explained to many members of the Photometry and Polarimetry Net, it is vital for precise cometary photometry to use standard stars that are close in the sky to the comet being observed. This is the only way in which we have any hope of getting adequate temporal coverage of Comet Halley, or for that matter of Comet Crommelin during the trial run. For that reason, we (together with M. Wolf) have selected a set of suitable stars along the paths of Comets Halley and Crommelin.

In the tables that follow, we have listed two types of stars. There are stars of early spectral type which are used primarily to calibrate the measured magnitudes into fluxes in the particular emission bands of interest. There are also several stars similar to the sun. These are used both to study the reflectivity of the cometary grains and also to determine the amount of contamination by continuum in the measurements of emission bands. We recommend that all photometric programs include observations of at least one standard of each type and observations of a total of at least three standards every night.

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The stars in the lists have been taken from a variety of sources. A few of them are actually among the primary standards which define the photometric system of the standard, narrowband cometary filters. Most of them are well observed in one or another stellar photometric systems and are therefore known not to be variables and have known broad-band magnitudes. Vanysek and Wolf have already begun a program to use the standard narrow-band cometary filters to determine magnitudes in this system for all the stars observable from the northern hemisphere. We will also arrange to obtain observations of those observable only from the southern hemisphere. We urge all photometric observers to consider using these standards for all types of photometric programs.

In general, one should use standards which set a few hours behind an evening comet (as Crommelin will be during the trial run) or which rise a few hours before a morning comet. Using this guideline, we have arranged the standards in a chronological order which indicates the order in which they will be most useful. Obviously the ordering is not meant to be followed rigidly.

M. F. A'Hearn
V. Vanysek
H. Campins

Table 1: Secondary B and G Standards Near Comet Crommelin

(in Chronological Order)

HD	SAO	α (1950)	δ	V	Sp
17081	148575	$02^h41^m44^s.5$	$-14^\circ04'10''$	4.44	F5V
20340	148864	03 13 27.4	-17 00 46	8.20	B3V
20630	111120	03 16 44.1	+03 11 16	4.83	G5V
26326	149412	04 07 01.5	-16 30 59	5.42	B3V
26923	111698	04 12 49.1	+06 03 49	6.31	G5IV
31726	150029	04 55 27.0	-14 18 27	5.90	B3V
32612	150109	05 01 35.2	-14 26 19	6.41	B3V
36591	132234	05 30 09.5	-01 37 36	5.33	B1V
37018	132320	05 32 55.1	-04 52 11	4.55	B1V
51219	114659	06 53 59.0	+01 14 10	7.42	G8V

During the official trial run, the comet moves from ($4\ 1/2^h$, $-14°$) to ($5\ 1/2^h$, $-16°$) and is an evening object. Thus the best standards for that particular period are HD 31726 through HD 37018 with either HD 26923 or HD 51219 as a solar comparison. The other stars allow coverage of the remainder of the apparition.

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Table 2: Secondary Flux Standards Along the Path of Comet Halley
(in Chronological Order)

HD	SAO	α (1950)	δ	V	Sp	Note
47 032	114129	$06^h34^m07^s.4$	$+04^\circ44'14''$	9.10	B2	-
41 753	95259	06 04 42.9	+14 46 34	4.424	B3V	g
36 351	112861	05 28 37.0	+03 15 21	5.447	B1.5V	g
34 078	57816	05 12 59.7	+34 15 23	5.96	09.5V	1
(HZ 14)	-	04 38 15.6	+10 53 57	13.94	DA	fs
26 912	111696	04 12 49.0	+08 46 07	4.27	B3IV	fs
24 760	56840	03 54 29.3	+39 52 01	2.883	B0.5V	g
22 951	56646	03 39 11.9	+33 48 21	4.967	B0.5V	g
16 908	75532	02 40 30.6	+27 29 43	4.66	B3V	4
3 379	91995	00 34 10.8	+14 57 43	5.88	B2.5IV	fs
191 639	144144	20 08 27.3	-08 59 28	6.49	B1V	1
175 191	187448	18 52 09.9	-26 21 38	2.086	B2.5V	g
166 197	209817	18 07 36.7	-33 48 39	6.119	B1V	g
149 438	184481	16 32 45.9	-28 06 49	2.818	B0V	g
137 432	206660	15 24 05.5	-36 35 37	5.434	B4V	g
133 955	225483	15 05 27.3	-45 05 23	4.05	B3V	4
122 980	224673	14 02 58.9	-40 56 26	4.34	B2V	4
104 337	157042	11 58 17.4	-19 22 49	(5.30)	B1.5V	2
99 171	222773	11 21 58.1	-42 23 38	6.12	B2V	g
97 991	138096	11 13 38.5	-03 11 55	7.387	B1V	g
(AGK3 $+5^\circ$ 1544)	-	10 35 55.1	+05 38 10	9.90	B5	-
84 971	137150	09 46 10.8	-02 28 48	8.65	B2V	3

NOTE

g - Geneva system
1 - D. Dunlap Observatory
2 - Walraven photometric system
3 - Washington photometric system
4 - u, v, b, y
fs - primary flux standard

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Table 3: Secondary G Standards Along the Path of Comet Halley
(in Chronological Order)

HD	SAO	α (1950)	δ	V	Sp
31 966	94253	$04^h49^m41^s.0$	+14°19′00″	6.760	G2IV-V
30 455	94136	04 45 46.2	+18 37 38	6.956	G2V
26 736	76516	04 11 32.2	+23 17 02	8.072	G3V
25 680	76438	04 02 22.4	+21 52 32	5.895	G5V
23 464	76168	03 43 15.2	+22 58 28	8.678	GOV
18 803	75696	02 59 27.7	+26 24 56	6.638	G8V
16 397	55739	02 35 30.9	+30 36 24	7.364	G1V
13 974	55420	02 13 59.5	+33 59 46	4.873	GOV
10 126	74857	01 36 45.6	+27 51 22	7.736	G8V
218 687	108437	23 07 27.5	+14 09 22	6.551	GOV
198 188	189735	20 46 21.9	-20 48 51	8.125	GOV
193 901	189226	20 20 38.8	-21 31 05	8.619	G3V
189 340	163168	19 57 04.3	-10 05 25	5.875	GOV
165 185	209710	18 03 00.9	-36 01 32	5.949	G5V
148 045	243848	16 24 27.7	-56 34 03	8.806	GOV
136 352	225697	15 18 25.1	-49 08 04	5.639	G2V
124 580	224798	14 12 27.6	-44 46 00	6.309	G1V
121 849	205054	13 55 42.9	-33 45 15	8.118	G5V
96 700	179558	11 05 31.5	-29 54 07	6.516	G2V
88 725	118176	10 11 32.0	+ 3 24 19	7.749	G1V
76 151	136389	08 51 50.6	+05 14 51	6.010	G3V

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RADIO SCIENCE

Goals For The IHW Trial Run

The purpose of the trial run on P/Crommelin for the radio science net is twofold: (1) it gives those observers who have not observed comets before or who have a novel technique for observations a chance to practice before the arrival of Halley's Comet; and (2) it provides a means to test the transfer of data from the individual observers through the discipline specialists to the Lead Centers. The official IHW trial run dates are 25-31 March 1984. In addition, the radio science net has designated several days near perihelion (8-11 February 1984) for radio investigations since the comet should be at its brightest for our purposes. Both time periods correspond to peaks in the flux density of the 18 cm OH lines. It is unfortunate that many of the experiments which are so promising for a bright comet like Halley may be very difficult for a moderately bright comet like P/Crommelin. Thus, for many members of the radio science net, observations of P/Crommelin may not be very fruitful. At the same time, we note that there are some experiments, notably the detection of the 18 cm OH lines, which would be very desirable during the trial run. Other attempts to observe the comet either via occultation techniques or by systems which have not yet made cometary observations are also strongly encouraged.

It is the hope of the discipline specialist team that the limited observations which are made, combined with the recent experience we have had in collecting observations of Comet IRAS-Araki-Alcock, will allow a sufficent test of the data collection and transfer process to prepare for the Halley observations. Any member of the radio sciences net who has not received IHW Newsletters Nos. 1-3 should contact the Lead Center. If you have not received the Radio Science Net Bulletins for September and November, 1983, please contact the Discipline Specialists.

Good Luck to all; we promise that Halley's Comet will be much brighter!

W. M. Irvine
F. P. Schloerb
R. D. Brown
E. Gerard
P. D. Godfrey

SPECTROSCOPY AND SPECTROPHOTOMETRY

Status Of The Net

The spectroscopic net presently consists of 376 members, in 41 countries, including members in 26 states in the USA. The Spectroscopy Center coordinates observations in the UV-optical spectral region (1,000-10,000 Å). More than half of the net members are observational spectroscopists, while the remainder have a wide range of interests associated with cometary research. These members include theorists interested in the effects of the solar wind and UV radiation

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on cometary ionospheres. Others are involved in studies of the origins of comets, cosmochemistry, and laboratory spectroscopy.

Spectroscopic Instrumentation

Observers have responded enthusiastically to our questionnaire regarding their instrumentation and their plans to study P/Halley. While the majority of net observers have access to plane grating Cassegrain spectrographs, others will be employing echelle and coude spectrographs, Fabry-Perot interferometers, prime-focus and Cassegrain CCD grisms, and objective prisms. Observations in the ultraviolet are being planned from Astro 1, an observing platform to be carried aboard the Space Shuttle in March 1986. About 60% of the observers have or are presently implementing digital detectors, including image dissector scanners, intensified Reticons, silicon-intensified target (SIT) vidicons, and charge-coupled devices (CCD'S). All of these digital detectors will, of course, provide significant gains in signal-to-noise and calibrated spectrophotometry.

Trial Run: P/Crommelin, 25-31 March 1984

We wish to remind spectroscopic observers of the forthcoming apparition of P/Crommelin (perihelion: 20 February 1984), when the International Halley Watch will conduct its Trial Run. The ephemeris for P/Crommelin, calculated by D. K. Yeomans, appears elsewhere in this Newsletter. We urge every net observer to participate in the Trial Run, 25-31 March 1984, on Comet Crommelin. The comet will be at a relatively large hour angle at the end of evening astronomical twilight during the last week in March, with a total magnitude increasing from 11.8 to 13.5. During this period, the best observations will be possible from the southern hemisphere, and from sites of low northern latitudes ($< 30°$). Here we want to especially encourage observers in Argentina, Brazil, Chile, Mexico, and Venezuela, as well as Texas, New Mexico, Arizona, California, and Hawaii, plus those in Australia, Indonesia, China (especially K'unming), India, Israel, Egypt, South Africa, Greece, Italy, France, Spain, Soviet Kazakh, Armenia, Georgia, and Crimea.

Interested observers who have access to telescopes of 1 meter aperture (or larger) in the period 25 February to 3 March 1984 (not included in the trial run period), are also encouraged to obtain spectra of P/Crommelin. During this week, the total magnitude will vary from 7.0 to 6.3. Although this week is not designated as part of the Trial Run, P/Crommelin will be at a heliocentric distance (r) of 0.75 AU, with an eastern elongation of 45°, thus being observable 1-2 hours after sunset. At r = 0.75 AU, the production rate for OH on P/Crommelin is predicted to be $2.4 - 2.6 \times 10^{29}$ sec^{-1} (Festou, 1983).

Observers are requested to immediately notify the Spectroscopy Center by telex (telex no. 667391) as soon as observations of P/Crommelin are obtained. To exercise the Trial Run, spectroscopic observers are encouraged to send copies as soon as possible of their digital data of P/Crommelin on magnetic tapes in FITS format (Flexible Image Transport System). The FITS format is described by D. C. Wells, E. W. Greisen, and R. H. Harten (1981). At the Spectroscopy Center, we are able to read nine track magnetic tapes at either 800 or 1600 bits per inch. Observers who are unable to put data in FITS format are requested to provide

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details of the tape format and density, and a sample printout of at least the first 1-2 blocks of the first tape record.

Spectrophotometric Standard Stars

Spectrograms which can be calibrated and converted to relative or absolute flux versus wavelength will require observations of standard stars at approximately the same zenith angle as the comet. Two widely used lists of spectrophotometric flux standard stars are being reprinted at Kitt Peak National Observatory for circulation to spectroscopic net observers. Net members who are observational spectroscopic will automatically receive copies of both of these publications, which will be distributed by the IHW Lead Center. These lists are:

1) Standard Stars for IIDS Observations, by K. Strom, 1977, (Tucson: KPNO).
2) IRS Standard Star Manual by J. Barnes and D. S. Hayes, 1982, (Tucson: KPNO).

Both of these lists contain:

Finding charts
1950 coordinates
Plots of F_ν versus λ (in graphical form)
F_ν versus λ (in tabular form).
Wavelength Range $\lambda\lambda$ 3200 - 8000 Å

The IRS (Intensified Reticon Scanner) standard stars cover $6 < m_v < 12$ mag, while the IIDS (Intensified Image Dissector Scanner) standard stars cover $11 < m_v < 14$ mag.

Two Dimensional Spectrograms Of P/Crommelin

P/Crommelin is expected to have a total magnitude of approximately 11.8 - 13.5 during 25-31 March 1984. During this time, observers with moderate resolution (Cassegrain, $\Delta\lambda$ = 3 - 10 Å) two-dimensional (long slit) spectrographs may be able to obtain intensity profiles, for example, in a given emission feature, (e.g. in CN, CO^+, H_2O^+, OH) measuring flux as a function of projected distance from the cometary nucleus in the solar and anti-solar directions. We will provide information on the expected position angle (measured north through east, i.e. orientation) of the tail, so spectrograph slits can be oriented in such a way as to secure spectra in the solar to anti-solar direction. Any concurrent observations of the orientation and extent of the tail may also be published by the IAU Central Bureau of Astronomical Telegrams, or may be received by IAU telegraph/telex subscribers.

Communications, IAU Telegrams

For the most up to date information on observations and predictions associated with P/Crommelin and P/Halley, and other comets as well, we urge observers to subscribe to the IAU Telegrams, and specifically to request that all information on comets (bright and faint ones) be sent to their institutes or observatories.

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Subscriptions to IAU Telegrams may be initiated by writing to:

Dr. B. G. Marsden
IAU Central Bureau for Astronomical Telegrams
Center for Astrophysics
60 Garden St.
Cambridge, MA 02138
USA

First Spectra Of P/Halley In 1983

Working at Kitt Peak National Observatory, Michael Belton (KPNO), and Hyron Spinrad and George Djorgovski (University of California, Berkeley) have succeeded in obtaining the first (to date) "threshold" spectrum of P/Halley on 10 October 1983 when the comet had a magnitude of >23 at a heliocentric distance of 8.8 AU. The spectrum shows a very noisy faint continuum at the predicted location of the comet. The spectrum was obtained using the KPNO 4 m telescope and the cryogenic camera at Cassegrain focus with a grism and a Texas Instruments CCD. A long slit (4 arc min) with a 3 arc sec slit width was employed, with the slit oriented in the apparent direction of motion of the comet in the sky. Further spectrscopic observations are planned using the same equipment in January 1984 by M. Belton, H. Spinrad, P. Wehinger, and S. Wyckoff.

In additon to P/Halley, the first spectroscopic observations of P/Crommelin for 1983 were obtained by Wehinger, Wyckoff, and J. Ford (ASU), on 13 November 1983 when Comet Crommelin was 1.8 AU from the sun and 17.5 mag. Their spectrum was recorded using the Steward Observatory's 2.3 m reflector (also located on Kitt Peak) with an intensified Reticon scanner at the Cassegrain focus. The spectrum covers the range $\lambda\lambda$ 3000-7000 Å.

Observers are cautioned to use as large-scale finding charts as possible to locate P/Halley and other very faint comets (m_v >15-16 mag), especially since both P/Crommelin and P/Halley are presently at low galactic latitudes in very crowded star fields. Charts made from the Palomar Observatory Sky Survey might, for example, be enlarged 10-20 times compared to the original POSS chart scale for use at the telescope or with a tv acquisition system. Of course, observers' needs will vary depending on the scale at the slit, whether an intensified vidicon (tv) viewing system is used, and what the telescope pointing accuracy is. Observers should keep in mind that P/Halley is predicted to be fainter than 15th mag until June 1985.

Icy Nucleus And The Development Of The Coma Of P/Halley

For observers with access to large telescopes (> 3 meters), low resolution ($\Delta\lambda$ = 20-50 Å) spectroscopy of P/Halley should become more feasible during 1984. Michael Belton and Pamela Melroy (MIT) have prepared a predicted light curve for P/Halley (Fig. 1) which is based on the 1910 observations and assumes that the nucleus is a slow rotator (~ 40 hours).

In the light curve, the secondary maxima occurring each year are due to the comet being at opposition, i.e. at a minimum comet-Earth distance. The

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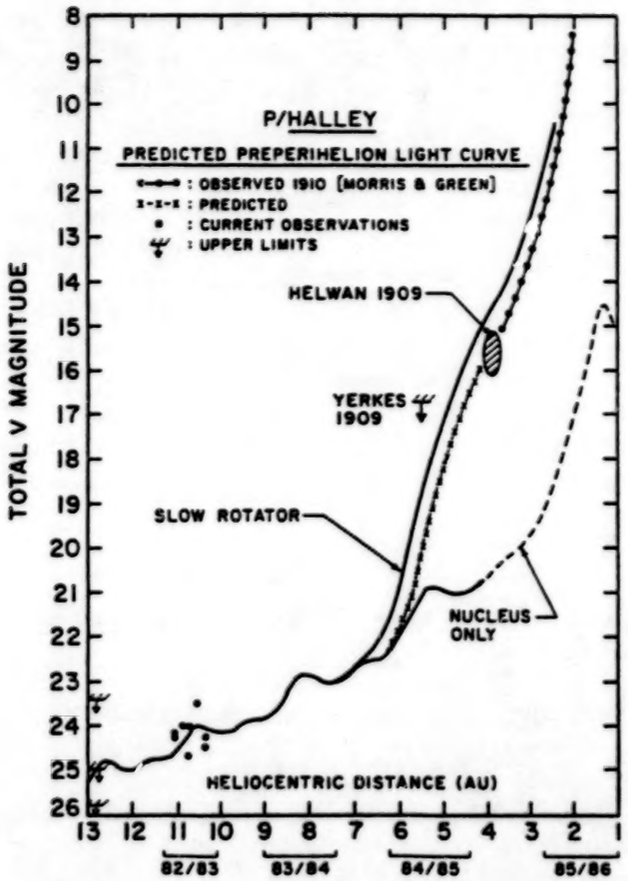

Figure 1. Predicted light curve for P/Halley 1982-86. This calculated light curve is presented with the permission of Michael J. S. Belton and Pamela Melroy, who thank Paul Weissman for his calculations of production rates from a pure H_2O ice nucleus.

extrapolated nuclear magnitude given in Fig. 1 corresponds to the brightness of P/Crommelin (V = 19.7 mag) at 3.0 AU when it was recovered. A great deal of uncertainty still exists as to when the rapid rise in brightness (i.e. development of the coma) will occur, since previous (1909) observations were limited to m_v <14. Also, spectroscopic observations at large heliocentric distances are heretofore unprecedented. From early 1984 to late 1985 the heliocentric distance of P/Halley will decrease from 8.5 to 5.5 AU. Monitoring the spectral evolution of P/Halley over the next 3-15 months will provide important information on the relative abundances of volatiles in the nucleus. Data obtained during this period are certain to lead to a significant improvement in our understanding of the structure and composition of the icy surface layers of comets.

Emission features expected to appear early in the development of cometary comae are described by P. Swings and L. Haser (1956) and in the papers cited in the review by S. Wyckoff (1982).

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Staff Additions, Spectroscopy Center, ASU Astronomy Group

Two Research Associates have joined the IHW Spectroscopy Center at Arizona State University. Dr. David Schleicher comes to us from the University of Maryland where he previously worked with Professor Michael A'Hearn, IHW Discipline Specialist for Photometry and Polarimetry. Dr. Mark Wagner joined us from Ohio State University. We are also pleased to note that a stellar spectroscopist, Professor Anne Cowley, joined the ASU Astronomy Group in September 1983. She was previously at the University of Michigan and Dominion Astrophysical Observatory. Dr. Barry Lutz (Lowell Observatory) continues to hold a position as Adjunct Professor at ASU.

S. Wyckoff
P. A. Wehinger
M. C. Festou

REFERENCES

Festou, M., 1983, IHW Newsletter, 3, 11.

Swings, P. and Haser, L., 1956, Atlas of Representative Cometary Spectra, (Liege: University of Liege).

Wells, C. C., Greisen, E. W., and Harten, R. H., 1981, Astron. Astrophys. Series, 44, 363.

Wyckoff, S., 1982, in Comets (Tucson: Univ. of Arizona Press), L. Wilkening, ed., p.3.

AMATEUR NOTES

At long last and after several printing delays the amateur observer's manual is now available. The full title is The International Halley Watch Amateur Observers' Manual for Scientific Comet Studies by Stephen J. Edberg. It is available from three publishers, and may eventually be distributed by booksellers in North America and Europe in addition. This book is required reading for all amateur astronomers planning on submitting observations to the IHW.

The version available from the Superintendent of Documents, U.S. Government Printing Office, Dept. 33, Washington, D.C. 20402, USA, (202) 783-3238 has been printed in two saddlestitched parts (i.e., each part is center-stapled like this newsletter). Part I, Methods is primarily descriptive how-to-do-it material, stock number 033-000-00888-1, $4.50. Part II, Ephemeris and Star Charts includes a daily ephemeris, star charts showing the comet's path over a six month period, and lists of standard and calibration stars, stock number 033-000-00889-9, $4.50. The payment may be by check or money order made payable to the Superintendent of Documents, or by charging to Visa or MasterCard accounts (include account number and expiration date). Include

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the stock number and title and allow at least four weeks for delivery by non-priority mail or United Parcel Service. Telephone orders or first class or air mail service may be arranged at (202) 783-3238, and the two mailing classes may also be arranged by mail in advance of the order.

Foreign orders must be in English and remitted in US dollars by check drawn on a US or Canadian bank, UNESCO coupon, International Postal Money Order made out to Superintendent of Documents, or by MasterCard or Visa. A 25% surcharge is made on foreign orders and surface mail is used. Contact the Superintendent prior to ordering if air mail service is desired.

Enslow Publishers, Bloy Street and Ramsey Avenue, Box 777, Hillside, NJ 07205, USA, and Sky Publishing Corp., 49 Bay State Road, Cambridge, MA 02238, USA are offering the same book perfect-bound (glued back) with both parts combined in a single volume. Their printing also contains the Halley observing conditions illustrations from D. Yeomans' Comet Halley Handbook. The price is $9.95 postage paid. Foreign orders must be in US funds drawn on a US bank or by international money order, and 10% for postage should be added.

The availability of translations of the manual in French, Russian, Polish, Japanese, Spanish, Bengali, Finnish, and Italian will be announced as each becomes available.

Astronomers in currency-controlled countries should send a letter to Stephen J. Edberg, Jet Propulsion Laboratory, 4800 Oak Grove Drive, T1166 NL4, Pasadena, CA 91109, USA. Arrangements will be made to send manuals to these requesters.

S. J. Edberg

PREDICTIONS OF OCCULTATIONS OF STARS BY COMET CROMMELIN

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USA

The predictions presented here were made by comparing cometary ephemerides with star and radio-source catalogs and tagging all appulses for which the closest comet-source geocentric separation is smaller than a specified threshold.

The star catalog we used comprises three components: the AGK3 catalog, the SAO catalog south of the celestial equator, and stars from the Perth 70 catalog not contained in the SAO catalog. For predictions involving radio sources, we used the Master List of Radio Sources, updated from Dixon (1970). For our purposes, we culled all duplicate entries in that catalog.

The provenance of the cometary orbital elements is B. G. Marsden (IAUC 3886). We have numerically integrated the cometary orbit, computing perturbations by all nine planets in the usual way.

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For occultations of stars we assumed a coma radius of 22,500 km (approximately a 1 arcmin diameter at 1 AU) and an appulse was logged if the minimum geocentric star-comet separation was less than the apparent angular radius of the comet plus twice the equatorial horizontal parallax, or 5 arcsec, whichever was greater. Radio-source occultations may involve cometary ion tails. Rather than attempt to model their extent and direction at this time, we have simply specified a very large cometary radius of 675,000 km (approximately a 30 arcmin diameter at 1 AU).

The accompanying tables list the predictions. For stars, star numbers such as +10 0832 refer to the AGK3 catalog, others to the SAO catalog. No events involving Perth 70 stars were found. (Very occasionally a prediction can be made for a star contained in the overlap zone of both catalogs.) "Star to asteroid (sic--our program was conceived for asteroid work!) direction" indicates S when the comet is south of the star at the time of minimum geocentric separation; otherwise N for "north." Star coordinates are referred to the equator of 1950 and epoch of date, and magnitudes are V for the SAO catalog and B for AGK3. Quantities listed for occultations of radio sources follow the style of the Master List of Radio Sources, except that if the flux is tabulated as -1, no value was quoted in MLRS.

In view of the present uncertaintites in cometary ephemerides (for example, that of P/Halley is thought to be accurate to ±2 arcmin at perihelion--mainly in the direction of motion--and better elsewhere), it is clear that the stellar occultation predictions may not be trustworthy far into the future. The present tabulations should therefore be treated with caution and may only be indicative of the frequency of occultation events to be anticipated. We expect to update the stellar predictions whenever new (and more accurate) cometary orbital elements become available. The accuracy requirements are far less stringent for occultations of radio sources, so we expect those predictions to change little as time goes by.

REFERENCE

Dixon, R. S., 1970, Astrophys. J. Suppl. Series, 20, (No. 180).

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APPULSES BY P/CROMMELIN

START DATE: 1983 NOV 1.000

GENERAL CATALOG SEARCH
SAO MAGNITUDES ARE V; AGK MAGNITUDES ARE PG

STAR NUMBER	MINIMUM SEPARATION (ARCSEC)	DATE (E.T.)	STAR TO ASTEROID DIRECTION	RA (1950.0) (EPOCH OF EVENT)	DEC	MAG	SOLAR ELONG
+11 2368	27.2	1983 NOV 3.84592	S	19 52 49.980	11 49 35.31	7.50	83.8
+11 2381	26.5	1983 NOV 7.22490	N	19 55 34.053	11 16 43.76	8.00	81.4
+10 2587	16.3	1983 NOV 13.18341	S	20 1 23.996	10 24 14.06	9.90	77.4
+09 2691	4.4	1983 NOV 20.05066	N	20 9 30.675	9 28 49.36	10.80	72.9
+09 2708	19.5	1983 NOV 22.47560	S	20 12 45.105	9 11 20.52	10.50	71.4
+08 2769	19.8	1983 NOV 27.14853	N	20 19 30.187	8 38 41.75	9.60	68.6
+07 2990	24.1	1983 DEC 9.41591	S	20 40 43.355	7 30 23.22	11.30	61.8
+06 2874	7.1	1983 DEC 18.17498	S	20 59 2.638	6 53 36.81	9.90	57.4
+06 2885	24.6	1983 DEC 20.64932	S	21 4 43.716	6 45 18.34	10.80	56.3
+05 3263	23.1	1984 JAN 14.39852	S	22 15 43.697	5 42 20.16	10.10	47.0
+05 3330	32.5	1984 JAN 25.19516	N	22 56 10.177	5 4 25.87	8.10	44.5
+02 0040	37.1	1984 FEB 13.33657	S	0 24 24.165	2 12 9.04	10.50	43.1
-01 0124	19.1	1984 FEB 24.04715	N	1 22 13.707	-1 11 10.07	10.80	45.1
129461	27.2	1984 FEB 27.14077	N	1 39 52.439	-2 24 41.44	7.90	46.2
130329	44.3	1984 MAR 12.82962	S	3 8 48.594	-9 3 35.50	9.00	54.5
130416	43.6	1984 MAR 14.07266	N	3 16 39.707	-9 39 40.15	9.10	55.5
148978	28.6	1984 MAR 15.59684	S	3 26 24.665	-10 20 32.01	8.10	56.6
149185	34.5	1984 MAR 18.76935	S	3 46 51.449	-11 45 20.38	9.00	59.2
149498	41.3	1984 MAR 22.93380	N	4 13 58.951	-13 30 27.27	8.90	62.7
149891	5.7	1984 MAR 27.74961	S	4 45 34.139	-15 15 24.46	7.90	66.9
149903	46.7	1984 MAR 27.87835	N	4 46 23.988	-15 18 50.58	7.90	67.0
150054	5.2	1984 MAR 29.50549	N	4 57 3.188	-15 49 37.56	8.70	68.4
150066	43.8	1984 MAR 29.61587	N	4 57 45.911	-15 52 18.70	9.00	68.5
150131	54.3	1984 MAR 30.36870	S	5 2 41.817	-16 4 26.71	8.60	69.2
150330	12.2	1984 APR 1.55166	S	5 16 51.509	-16 42 14.17	9.20	71.0
150377	8.4	1984 APR 1.97695	N	5 19 36.063	-16 49 19.58	9.50	71.4
150943	14.5	1984 APR 7.31723	N	5 53 31.823	-18 0 58.08	8.80	75.7
150972	22.4	1984 APR 7.60952	S	5 55 21.384	-18 3 34.75	6.92	75.9
151817	46.7	1984 APR 15.07920	S	6 40 10.897	-19 3 1.96	8.80	81.1
152027	9.1	1984 APR 16.76093	N	6 49 45.246	-19 12 2.25	8.30	82.2
152169	46.9	1984 APR 17.79307	S	6 55 31.908	-19 15 12.23	8.60	82.7
152362	47.0	1984 APR 19.22924	S	7 3 25.981	-19 19 53.48	9.10	83.5
152814	4.0	1984 APR 22.62604	N	7 21 29.393	-19 27 36.34	8.80	85.2
153544	38.0	1984 APR 28.57255	S	7 50 56.903	-19 27 33.09	9.20	87.5
154527	36.7	1984 MAY 9.48364	S	8 38 10.399	-19 7 12.39	9.00	89.7
154670	5.4	1984 MAY 11.92075	N	8 47 37.121	-19 1 41.43	8.80	89.9
155361	6.9	1984 MAY 26.11819	S	9 35 58.978	-18 26 28.54	9.20	88.9
156042	19.9	1984 JUN 14.98117	S	10 29 33.663	-18 3 17.57	9.00	83.5
156077	21.7	1984 JUN 16.17028	S	10 32 23.314	-18 3 52.14	9.00	83.1
181732	5.9	1984 SEP 27.52572	N	13 29 28.494	-23 35 21.36	8.80	28.4
181835	5.3	1984 OCT 2.95763	S	13 36 53.428	-24 0 33.30	9.60	25.2
206733	2.1	1985 JAN 15.80167	N	15 28 40.754	-30 53 40.67	9.71	58.4

END DATE: 1985 FEB 3.000

APPULSES BY P/CROMMELIN

START DATE: 1983 NOV 1.000

RADIO CATALOG SEARCH

SOURCE ID	MINIMUM SEP (ARCSEC)	SOURCE TO COMET DIRECTION	DATE (ET)	RA (1950.0)	DEC	SOLAR ELONG	FREQ (MHZ)	FLUX (JY)	SEQ NO
MC2 1952+119	2.8	S	1983 NOV 3.18666	19 52 19.100	11 55 43.00	84.3	408	0.790	72161
MC2 1957+109	54.8	N	1983 NOV 9.32502	19 57 27.900	10 57 4.00	80.0	408	0.250	72380
4C+10.62	242.1	S	1983 NOV 13.75869	20 2 8.400	10 22 42.00	77.0	179	3.600	72559
MC2 2002+103	164.7	S	1983 NOV 13.79909	20 2 8.600	10 21 13.00	77.0	408	2.300	72560
OW+103	196.8	S	1983 NOV 13.88157	20 2 15.000	10 21 0.00	76.9	1415	0.530	72565
4CP10.62	466.8	S	1983 NOV 14.01254	20 2 32.000	10 23 54.00	76.8	178	3.400	72579
MSH 20+001	550.3	N	1983 NOV 24.36336	20 15 12.000	8 49 0.00	70.3	85	15.000	73185
OW+048	219.8	S	1983 DEC 2.46467	20 28 8.000	8 10 0.00	65.5	1415	0.640	73858
4C+07.54	33.4	N	1983 DEC 13.49591	20 48 54.500	7 11 12.00	59.7	179	2.800	75031
OW+081.6	391.1	N	1983 DEC 13.56569	20 49 0.000	7 5 0.00	59.7	1415	0.160	75038
4CP07.54	418.8	N	1983 DEC 13.74319	20 49 22.000	7 3 48.00	59.6	178	2.300	75061
PKS2203+05	555.7	N	1984 JAN 10.85395	22 3 47.000	5 41 18.00	48.1	408	1.700	78539
4C+05.82	440.1	N	1984 JAN 10.86430	22 3 49.400	5 43 12.00	48.1	179	2.400	78554
OI+007	509.5	N	1984 JAN 10.88376	22 3 53.000	5 42 0.00	48.1	1415	0.990	78562
4C+05.83	479.3	S	1984 JAN 12.84933	22 10 28.000	5 53 48.00	47.5	179	2.200	78880
OI+066	548.3	N	1984 JAN 20.99651	22 39 38.000	5 13 0.00	45.3	1415	0.270	80411
DA595	764.0	S	1984 JAN 28.58038	23 10 18.000	5 0 0.00	43.9	1420	2.000	81958
4C+05.85	770.5	S	1984 JAN 28.58180	23 10 18.400	5 0 6.00	43.9	179	9.600	81960
MSH 23+004	182.9	S	1984 JAN 28.64131	23 10 30.000	4 50 0.00	43.9	85	15.000	81978
PRF873	291.0	N	1984 JAN 28.66444	23 10 33.000	4 42 0.00	43.9	178	14.000	81983
MA 2318+047	447.1	S	1984 JAN 30.43586	23 18 15.600	4 43 15.00	43.6	1400	0.140	82389
OI+044	443.7	N	1984 FEB 1.09028	23 25 27.000	4 17 0.00	43.4	1415	0.720	82772
4C+04.79	13.0	N	1984 FEB 1.09497	23 25 31.400	4 24 6.00	43.4	179	2.400	82783
PKS2325+04	113.4	N	1984 FEB 1.09996	23 25 32.000	4 22 24.00	43.4	408	3.700	82784
4C+04.80	204.7	S	1984 FEB 1.55297	23 27 35.900	4 24 18.00	43.4	179	2.000	82896
OI+059	341.2	N	1984 FEB 3.09946	23 34 32.000	4 3 0.00	43.2	1415	0.240	83231
GC2338+04	801.1	S	1984 FEB 3.90398	23 38 23.500	4 15 1.00	43.2	5000	0.480	83434
4C+04.81	770.9	S	1984 FEB 3.90597	23 38 23.800	4 14 30.00	43.2	179	9.200	83435
PKS2338+04	747.1	S	1984 FEB 3.91821	23 38 27.000	4 14 0.00	43.2	408	5.400	83440
OI+068	489.4	N	1984 FEB 4.31901	23 40 8.000	3 50 0.00	43.1	1415	0.300	83537
OI+070	606.3	S	1984 FEB 4.66089	23 41 53.000	4 5 0.00	43.1	1415	0.150	83596
OI+075	146.9	N	1984 FEB 5.35998	23 45 3.000	3 46 0.00	43.1	1415	0.240	83728
4C+04.82	802.3	S	1984 FEB 5.34673	23 45 7.800	4 1 48.00	43.1	179	2.700	83733
OI+094	372.6	S	1984 FEB 7.65404	23 56 5.000	3 31 0.00	43.0	1415	0.340	84334
PKS2356+033	244.4	N	1984 FEB 7.68429	23 56 7.600	3 20 30.00	43.0	2700	0.219	84339
4C+03.61	426.2	S	1984 FEB 7.66149	23 56 7.700	3 31 48.00	43.0	179	2.700	84340
PKS0012+027	125.0	N	1984 FEB 10.96667	0 12 19.600	2 42 48.00	43.0	2700	0.067	723
OB+029	696.8	S	1984 FEB 11.87409	0 17 4.000	2 44 0.00	43.0	1415	0.320	1002
PKS0017+026	573.1	S	1984 FEB 11.90097	0 17 10.700	2 41 36.00	43.0	2700	0.142	1007
AO 0024+02	115.7	N	1984 FEB 13.41357	0 24 46.000	2 8 30.00	43.1	430	0.500	1456
MSH 00+006	878.9	N	1984 FEB 14.45764	0 30 0.000	1 40 0.00	43.2	85	68.000	1753

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PKS0046+011	305.9	S	1984	FEB	17.45842	0 46 5.700	1 8 42.00	43.6	2700	0.078	3106
PKS0054+006	269.9	S	1984	FEB	19.09148	0 54 53.000	0 37 42.00	43.9	2700	0.082	3618
3C037	491.3	N	1984	FEB	22.84870	1 15 22.000	-0 52 0.00	44.8	159	12.000	4972
OC-029	637.6	N	1984	FEB	23.24042	1 17 31.000	-1 3 0.00	44.9	1415	0.340	5106
LHE029	581.9	N	1984	FEB	24.21274	1 23 0.000	-1 24 0.00	45.2	408	22.000	5426
3C040.0	908.4	N	1984	FEB	24.33283	1 23 35.000	-1 32 0.00	45.2	178	24.000	5455
BEH04	908.4	N	1984	FEB	24.33283	1 23 35.000	-1 32 0.00	45.2	178	24.000	5454
PRP073	15.3	N	1984	FEB	24.34888	1 23 56.000	-1 18 0.00	45.2	178	27.000	5483
MSH 01-009	45.1	N	1984	FEB	26.36394	1 35 24.000	-2 6 0.00	45.9	85	13.000	6282
OC-060	136.3	S	1984	FEB	26.36023	1 35 26.000	-2 3 0.00	45.9	1415	0.490	6288
4C-02.07	261.9	S	1984	FEB	26.38559	1 35 37.000	-2 1 36.00	45.9	179	2.800	6299
MSH 01-010	787.3	S	1984	FEB	27.75926	1 43 42.000	-2 27 0.00	46.4	85	12.000	6686
OD-018	989.2	N	1984	MAR	3.45259	2 10 46.000	-4 58 0.00	48.6	1415	0.360	8261
MSH 02-004	750.8	N	1984	MAR	3.44526	2 10 48.000	-4 54 0.00	48.6	85	8.000	8268
OD-060	259.6	S	1984	MAR	7.53497	2 35 54.000	-6 31 0.00	50.9	1415	0.160	10138
NRAO110	639.2	N	1984	MAR	8.10648	2 39 7.000	-7 1 23.00	51.3	750	1.320	10311
PKS0239-07	625.7	N	1984	MAR	8.11118	2 39 9.000	-7 1 18.00	51.3	1410	0.800	10316
PKS 0239-07	573.3	N	1984	MAR	8.10946	2 39 9.400	-7 0 25.00	51.3	2700	0.420	10318
OD-094	951.0	S	1984	MAR	10.86972	2 56 47.000	-7 54 0.00	53.1	1415	0.360	11303
OD-097	854.0	S	1984	MAR	11.09853	2 58 11.000	-8 2 0.00	53.3	1415	0.300	11366
PKS 0259-080	1122.7	S	1984	MAR	11.33095	2 59 43.600	-8 4 16.00	53.5	2700	0.280	11472
OE-002	1126.9	N	1984	MAR	11.64516	3 0 58.000	-8 49 0.00	53.7	1415	0.230	11552
OE-014	687.1	S	1984	MAR	12.71081	3 8 16.000	-8 50 0.00	54.5	1415	0.250	11913
OE-027	484.9	S	1984	MAR	14.02855	3 16 33.000	-9 30 0.00	55.4	1415	0.270	12479
OE-158	367.0	S	1984	MAR	16.84566	3 34 32.000	-10 49 0.00	57.6	1415	0.260	13537
OE-164.6	180.3	N	1984	MAR	17.52604	3 38 45.000	-11 16 0.00	58.2	1415	0.280	13761
OE-171	973.8	S	1984	MAR	18.11161	3 42 53.000	-11 13 0.00	58.7	1415	0.420	13992
PKS 0348-120	482.3	N	1984	MAR	19.09753	3 48 49.900	-12 2 11.00	59.5	2700	0.500	14329
OE-182	687.4	N	1984	MAR	19.11749	3 48 54.000	-12 6 0.00	59.5	1415	0.440	14334
OE-193	364.4	N	1984	MAR	20.13836	3 55 38.000	-12 27 0.00	60.3	1415	0.170	14754
OF-111.1	720.9	N	1984	MAR	21.83459	4 6 36.000	-13 15 0.00	61.8	1415	0.500	15447
OF-111	1045.2	S	1984	MAR	21.77359	4 6 42.000	-12 45 0.00	61.7	1415	0.460	15455
PKS 0406-127	959.1	S	1984	MAR	21.78709	4 6 45.800	-12 46 43.00	61.7	2700	0.590	15458
OF-119	491.7	S	1984	MAR	22.56250	4 11 42.000	-13 13 0.00	62.4	1415	0.180	15778
OF-133	108.6	S	1984	MAR	23.87416	4 20 11.000	-13 50 0.00	63.5	1415	0.270	16224
PKS 0420-139	148.8	N	1984	MAR	23.88495	4 20 11.100	-13 54 25.00	63.5	2700	0.250	16225
PKS 0432-148	986.7	N	1984	MAR	25.72337	4 32 1.800	-14 49 10.00	65.1	2700	0.290	17015
MSH 04-114	690.0	N	1984	MAR	26.45367	4 36 54.000	-15 0 0.00	65.8	85	7.300	17306
OF-174	831.1	S	1984	MAR	27.55365	4 44 29.000	-14 58 0.00	66.7	1415	0.190	17736
PKS 0457-15	660.8	S	1984	MAR	29.59659	4 57 47.800	-15 40 26.00	68.5	2700	0.280	18583
OF-197	871.9	S	1984	MAR	29.59755	4 57 51.000	-15 37 0.00	68.5	1415	0.300	18586
PKS0457-15	712.6	S	1984	MAR	29.60810	4 57 53.000	-15 39 48.00	68.5	1410	0.500	18591
OF-198	643.3	N	1984	MAR	29.77182	4 58 39.000	-16 5 0.00	68.7	1415	0.210	18628
OG-106	33.4	N	1984	MAR	30.48721	5 3 27.000	-16 8 0.00	69.3	1415	0.620	18889
OG-125.4	377.2	S	1984	APR	1.28911	5 15 14.000	-16 32 0.00	70.8	1415	0.330	19539
MSH 05-106	298.6	S	1984	APR	1.33277	5 15 30.000	-16 34 0.00	70.8	85	16.000	19556
OG-143	193.2	N	1984	APR	3.00236	5 26 10.000	-17 8 0.00	72.2	1415	0.190	20243
MSH 05-116	378.1	S	1984	APR	4.36791	5 35 0.000	-17 18 0.00	73.4	85	15.000	20760
OG-161	1009.5	N	1984	APR	4.59891	5 36 14.000	-17 44 0.00	73.5	1415	0.240	20829
MSH 05-120	549.9	S	1984	APR	5.73632	5 43 42.000	-17 33 0.00	74.5	85	17.000	21286
OG-173	698.1	S	1984	APR	5.77223	5 43 57.000	-17 31 0.00	74.5	1415	0.960	21298

PKS0544-17	925.5	S	1984 APR	5.80882	5 44 13.000	-17 27 42.00	74.5	408	3.800	21306
OG-181	556.0	S	1984 APR	6.57114	5 48 57.000	-17 43 0.00	75.1	1415	0.180	21566
OG-192	1106.9	S	1984 APR	7.64270	5 55 43.000	-17 46 0.00	75.9	1415	0.300	21894
OH-117.9	876.8	S	1984 APR	10.09421	6 10 45.000	-18 14 0.00	77.8	1415	0.200	22748
OH-154	377.0	S	1984 APR	13.77297	6 32 38.000	-18 50 0.00	80.3	1415	0.190	24098
DGVW038	878.4	N	1984 APR	13.95713	6 33 36.000	-19 12 0.00	80.4	400	95.000	24142
OH-162	737.5	N	1984 APR	14.70031	6 37 56.000	-19 14 0.00	80.9	1415	0.230	24411
MC1 0650-193	579.6	N	1984 APR	16.89530	6 50 28.500	-19 22 6.00	82.2	408	0.250	25119
MSH 06-114	35.9	N	1984 APR	17.37541	6 53 12.000	-19 15 0.00	82.5	85	7.600	25286
MC1 0656-195	960.9	N	1984 APR	18.05268	6 56 55.100	-19 32 55.00	82.9	408	0.290	25478
PKS0702-19	389.3	S	1984 APR	19.12866	7 2 54.000	-19 13 54.00	83.5	408	2.700	25794
BG 0703-19	688.2	S	1984 APR	19.15497	7 3 3.400	-19 9 0.00	83.5	408	1.800	25802
OI-105	327.2	N	1984 APR	19.18645	7 3 11.000	-19 26 0.00	83.5	1415	0.510	25814
MSH 07-102	465.5	S	1984 APR	19.25656	7 3 36.000	-19 13 0.00	83.5	85	10.000	25834
MC1 0711-193	40.5	S	1984 APR	20.81457	7 11 58.300	-19 23 54.00	84.3	408	0.430	26317
MC1 0712-194	38.2	N	1984 APR	20.85793	7 12 12.000	-19 25 18.00	84.4	408	0.280	26329
OI-121	251.1	N	1984 APR	20.93439	7 12 36.000	-19 29 0.00	84.4	1415	0.230	26339
MC1 0713-195	494.4	N	1984 APR	21.05122	7 13 12.800	-19 33 17.00	84.5	408	0.250	26363
OI-123	666.6	S	1984 APR	21.07974	7 13 24.000	-19 14 0.00	84.5	1415	0.700	26374
BG 0713-19	7.3	S	1984 APR	21.08885	7 13 25.700	-19 25 0.00	84.5	408	1.800	26378
BI 0713-19	411.1	N	1984 APR	21.10443	7 13 29.900	-19 32 0.00	84.5	408	1.500	26381
OI-126.9	476.8	N	1984 APR	21.60636	7 16 9.000	-19 34 0.00	84.7	1415	0.240	26481
CC 233-02.6	675.8	S	1984 APR	21.98502	7 18 10.000	-19 15 24.00	84.9	408	0.740	26575
MC1 0720-193	295.7	S	1984 APR	22.39539	7 20 17.900	-19 22 19.00	85.1	408	0.500	26731
OI-136	29.0	N	1984 APR	22.60880	7 21 24.000	-19 28 0.00	85.2	1415	0.190	26791
MC1 0723-194	82.8	S	1984 APR	23.05889	7 23 43.700	-19 26 39.00	85.4	408	0.260	26949
MC1 0724-192	621.8	S	1984 APR	23.25154	7 24 45.500	-19 17 52.00	85.5	408	0.580	26998
DCC234.7-00.2	598.5	S	1984 APR	24.23759	7 29 45.000	-19 19 0.00	85.9	2700	0.700	27325
MSH 07-111	520.3	N	1984 APR	25.12411	7 34 12.000	-19 38 0.00	86.3	85	11.000	27613
OI-166.7	682.0	S	1984 APR	26.29763	7 40 0.000	-19 18 0.00	86.7	1415	0.270	27925
OI-171	707.4	N	1984 APR	26.88012	7 42 51.000	-19 41 0.00	86.9	1415	0.180	28095
MC1 0743-194	159.1	S	1984 APR	26.95706	7 43 12.900	-19 26 32.00	87.0	408	0.300	28106
MC1 0745-196	617.5	N	1984 APR	27.45295	7 45 37.000	-19 39 15.00	87.1	408	0.300	28237
MC1 0745-193	545.9	S	1984 APR	27.50477	7 45 51.300	-19 19 50.00	87.2	408	0.230	28261
OI-180	620.6	N	1984 APR	27.95350	7 48 1.000	-19 39 0.00	87.3	1415	0.360	28359
MSH 07-119	367.2	S	1984 APR	28.64808	7 51 18.000	-19 22 0.00	87.5	85	17.000	28550
MC1 0751-196	705.9	N	1984 APR	28.76010	7 51 50.700	-19 39 47.00	87.6	408	1.790	28577
PKS0752-19	591.0	N	1984 APR	28.83584	7 52 12.000	-19 37 48.00	87.6	408	3.800	28591
MC1 0752-195	454.4	N	1984 APR	28.96745	7 52 49.000	-19 35 24.00	87.6	408	1.050	28629
BI 0752-198	131.5	N	1984 APR	28.98850	7 52 54.600	-19 30 0.00	87.6	408	1.100	28635
MC1 0752-193	279.3	S	1984 APR	28.99460	7 52 55.900	-19 23 9.00	87.6	408	0.230	28636
MC1 0756-194	137.5	N	1984 APR	29.77779	7 56 35.500	-19 29 16.00	87.9	408	0.500	28792
MC1 0758-195	477.8	N	1984 APR	30.14222	7 58 17.000	-19 34 30.00	88.0	408	0.200	28862
MC1 0805-195	484.4	N	1984 MAY	1.64562	8 5 7.700	-19 32 30.00	88.4	408	0.490	29209
MC1 0805-194	187.0	N	1984 MAY	1.82164	8 5 54.600	-19 27 16.00	88.4	408	0.370	29255
MC1 0807-196	776.3	N	1984 MAY	2.24130	8 7 48.200	-19 36 24.00	88.5	408	0.240	29379
OJ-113	153.2	N	1984 MAY	2.25241	8 7 50.000	-19 26 0.00	88.5	1415	0.250	29381
MC1 0811-194	290.2	N	1984 MAY	3.00859	8 11 11.000	-19 26 58.00	88.7	408	0.440	29612
MC1 0818-194	480.8	N	1984 MAY	4.72398	8 18 37.700	-19 26 49.00	89.1	408	0.910	30222
MC1 0819-194	643.6	N	1984 MAY	4.88950	8 19 20.500	-19 29 11.00	89.1	408	0.950	30297
OJ-149	32.5	N	1984 MAY	7.15208	8 28 47.000	-19 14 0.00	89.4	1415	0.250	30888

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MC1 0829-192	215.7	N	1984 MAY 7.23810	8 29 8.700	-19 16 51.00	89.5	408	0.240	30901
MC1 0833-193	542.6	N	1984 MAY 8.26481	8 33 20.200	-19 19 51.00	89.6	408	0.380	31161
OJ-163.3	116.9	S	1984 MAY 9.43243	8 37 58.000	-19 6 0.00	89.7	1415	0.210	31238
OK-120.3	591.2	S	1984 MAY 18.75244	9 12 10.000	-18 34 0.00	89.8	1415	0.630	33411
OK-148.2	572.2	S	1984 MAY 23.85586	9 28 55.000	-18 22 0.00	89.3	1415	0.500	34377
RWH0946-18	48.2	S	1984 MAY 29.59[illegible]0	9 46 22.000	-18 19 0.00	88.3	408	0.500	35706
PKS 0946-18	303.4	S	1984 MAY 29.60595	9 46 23.000	-18 14 44.00	88.3	2700	0.380	35707
OK-177.4	406.7	S	1984 MAY 29.61346	9 46 24.000	-18 13 0.00	88.3	1415	1.450	35709
PKS0946-18	256.2	S	1984 MAY 29.61656	9 46 25.000	-18 15 30.00	88.3	408	3.500	35711
MSH 09-112	264.7	S	1984 MAY 29.81704	9 47 0.000	-18 15 0.00	88.2	85	12.000	35737
OK-199.1	209.2	N	1984 JUN 3.20433	9 59 25.000	-18 16 0.00	87.2	1415	0.220	36485
MSH 10-104	425.0	N	1984 JUN 7.19062	10 10 6.000	-18 15 0.00	86.1	85	14.000	37105
QL29	264.4	N	1984 JUN 7.53754	10 11 0.000	-18 12 0.00	86.0	240	9.500	37160
MSH 10-110	341.0	N	1984 JUN 12.52096	10 23 36.000	-18 10 0.00	84.4	85	10.000	37937
OL-170	289.2	N	1984 JUN 20.31199	10 41 58.000	-18 9 0.00	81.5	1415	0.310	38945
OM-110.8	98.6	N	1984 JUL 1.67197	11 6 25.000	-18 16 0.00	76.8	1415	0.190	40758
OM-140.5	145.8	S	1984 JUL 10.69595	11 24 18.000	-18 28 0.00	72.6	1415	0.460	41927
OM-164.6	296.8	N	1984 JUL 18.47811	11 38 46.000	-18 54 0.00	68.7	1415	0.280	42820
B1 1206-19	266.5	N	1984 AUG 3.67883	12 6 55.900	-19 44 0.00	60.2	408	1.200	44681
MC1 1214-199	49.2	S	1984 AUG 8.46555	12 14 52.900	-19 56 13.00	57.6	408	0.210	45182
MC1 1218-200	113.9	S	1984 AUG 10.53010	12 18 14.800	-20 2 57.00	56.4	408	0.220	45452
MC1 1220-201	127.6	S	1984 AUG 11.98559	12 20 35.700	-20 8 19.00	55.6	408	0.310	45582
MC1 1231-206	117.1	S	1984 AUG 19.15684	12 31 56.800	-20 37 5.00	51.6	408	0.260	46226
OM-262	47.4	S	1984 AUG 22.47800	12 37 5.000	-20 52 0.00	49.7	1415	0.190	46514
MC1 1249-214	105.0	S	1984 AUG 30.58118	12 49 24.900	-21 25 52.00	45.0	408	0.920	47382
B1 1249-21	14.5	N	1984 AUG 30.62296	12 49 26.900	-21 28 0.00	45.0	408	1.400	47390
OM-289.1	146.3	S	1984 SEP 2.25569	12 53 25.000	-21 37 0.00	43.4	1415	0.190	47723
MC1 1253-216	47.3	S	1984 SEP 2.59793	12 53 54.000	-21 40 8.00	43.2	408	0.170	47781
OP-251.1	182.7	S	1984 SEP 28.31664	13 30 37.000	-23 36 0.00	27.9	1415	0.200	50337
OQ-215.5	6.4	S	1984 OCT 27.82776	14 9 17.000	-25 55 0.00	13.0	1415	0.210	52662
OQ-217.2	60.9	N	1984 OCT 28.69986	14 10 21.000	-26 0 0.00	12.8	1415	0.270	52750
OQ-264.1	162.4	S	1984 NOV 21.29653	14 38 26.000	-27 38 0.00	17.3	1415	0.190	54477
MSH 15-203	51.5	N	1984 DEC 17.84839	15 5 48.000	-29 23 0.00	35.1	85	35.000	56125
OR-335	129.9	S	1985 JAN 4.98457	15 21 14.000	-30 20 0.00	49.3	1415	0.800	57105

END DATE: 1985 FEB 3.000

EPHEMERIS (WITH PERTURBATIONS) FOR P/CROMMELIN

YR	MN	DY	HR	J.D.	R.A. 1950.0	DEC.	R.A. APPN	DEC.	DELTA	DELDOT	R	RDOT	TMAG	NMAG	THETA	BETA	MOON
1984	1	1	.0	2445700.5	21 33.906	+ 6 12.94	21 35.566	+ 6 21.99	1.49	-14.78	1.17	-22.49	.0	18.4	51.5	41.1	75
1984	1	2	.0	2445701.5	21 36.737	+ 6 10.58	21 38.398	+ 6 19.71	1.49	-15.01	1.16	-22.41	.0	18.4	51.2	41.4	64
1984	1	3	.0	2445702.5	21 39.613	+ 6 8.25	21 41.275	+ 6 17.46	1.48	-15.23	1.15	-22.32	.0	18.4	50.9	41.7	54
1984	1	4	.0	2445703.5	21 42.534	+ 6 5.96	21 44.198	+ 6 15.25	1.47	-15.45	1.13	-22.23	.0	18.4	50.4	42.0	44
1984	1	5	.0	2445704.5	21 45.501	+ 6 3.70	21 47.166	+ 6 13.07	1.46	-15.67	1.12	-22.13	.0	18.3	50.1	42.3	35
1984	1	6	.0	2445705.5	21 48.514	+ 6 1.46	21 50.180	+ 6 10.91	1.45	-15.89	1.11	-22.02	.0	18.3	49.7	42.6	27
1984	1	7	.0	2445706.5	21 51.574	+ 5 59.23	21 53.242	+ 6 8.75	1.44	-16.10	1.09	-21.90	.0	18.3	49.4	43.0	23
1984	1	8	.0	2445707.5	21 54.682	+ 5 57.39	21 56.351	+ 6 6.60	1.43	-16.31	1.08	-21.77	.0	18.3	49.0	43.3	23
1984	1	9	.0	2445708.5	21 57.838	+ 5 55.75	21 59.508	+ 6 4.43	1.42	-16.52	1.07	-21.64	.0	18.2	48.7	43.7	27
1984	1	10	.0	2445709.5	22 1.043	+ 5 54.48	22 2.714	+ 6 2.24	1.41	-16.73	1.06	-21.49	.0	18.2	48.4	44.1	35
1984	1	11	.0	2445710.5	22 4.297	+ 5 53.48	22 5.969	+ 6 .02	1.40	-16.92	1.04	-21.33	.0	18.2	48.1	44.4	44
1984	1	12	.0	2445711.5	22 7.601	+ 5 52.83	22 9.275	+ 5 57.74	1.39	-17.12	1.03	-21.16	.0	18.1	47.8	44.8	53
1984	1	13	.0	2445712.5	22 10.956	+ 5 52.42	22 12.631	+ 5 55.41	1.38	-17.31	1.02	-20.98	.0	18.1	47.5	45.2	64
1984	1	14	.0	2445713.5	22 14.362	+ 5 52.23	22 16.038	+ 5 52.99	1.37	-17.50	1.01	-20.79	.0	18.1	47.2	45.7	75
1984	1	15	.0	2445714.5	22 17.820	+ 5 52.25	22 19.498	+ 5 50.49	1.36	-17.68	1.00	-20.59	.0	18.0	46.9	46.1	87
1984	1	16	.0	2445715.5	22 21.330	+ 5 52.47	22 23.010	+ 5 47.88	1.35	-17.85	.98	-20.36	12.9	18.0	46.6	46.5	99
1984	1	17	.0	2445716.5	22 24.894	+ 5 52.90	22 26.575	+ 5 45.14	1.34	-18.02	.97	-20.12	12.7	18.0	46.3	47.0	112
1984	1	18	.0	2445717.5	22 28.511	+ 5 53.54	22 30.194	+ 5 42.26	1.33	-18.19	.96	-19.87	12.5	18.0	46.1	47.5	124
1984	1	19	.0	2445718.5	22 32.183	+ 5 54.41	22 33.868	+ 5 39.23	1.32	-18.35	.95	-19.60	12.3	17.9	45.8	48.0	137
1984	1	20	.0	2445719.5	22 35.910	+ 5 55.53	22 37.596	+ 5 36.01	1.31	-18.50	.94	-19.32	12.1	17.9	45.6	48.5	149
1984	1	21	.0	2445720.5	22 39.693	+ 5 56.91	22 41.381	+ 5 32.60	1.30	-18.64	.93	-19.02	11.9	17.9	45.3	49.0	159
1984	1	22	.0	2445721.5	22 43.532	+ 5 58.57	22 45.221	+ 5 28.98	1.29	-18.78	.92	-18.70	11.7	17.8	45.1	49.5	162
1984	1	23	.0	2445722.5	22 47.428	+ 6 0.52	22 49.119	+ 5 25.11	1.28	-18.90	.91	-18.36	11.5	17.8	44.9	50.1	155
1984	1	24	.0	2445723.5	22 51.381	+ 6 2.77	22 53.073	+ 5 20.99	1.27	-19.03	.90	-18.01	11.3	17.8	44.7	50.6	145
1984	1	25	.0	2445724.5	22 55.392	+ 6 5.32	22 57.086	+ 5 16.59	1.26	-19.14	.89	-17.63	11.1	17.8	44.5	51.2	134
1984	1	26	.0	2445725.5	22 59.461	+ 6 8.17	23 1.157	+ 5 11.89	1.25	-19.25	.88	-17.23	10.9	17.7	44.3	51.8	122
1984	1	27	.0	2445726.5	23 3.589	+ 6 11.32	23 5.286	+ 5 6.86	1.23	-19.34	.87	-16.81	10.7	17.7	44.1	52.4	111
1984	1	28	.0	2445727.5	23 7.775	+ 6 14.76	23 9.474	+ 5 1.49	1.22	-19.43	.86	-16.37	10.5	17.7	44.0	53.0	99
1984	1	29	.0	2445728.5	23 12.021	+ 6 18.49	23 13.721	+ 4 55.74	1.21	-19.51	.85	-15.90	10.3	17.7	43.8	53.7	88
1984	1	30	.0	2445729.5	23 16.326	+ 6 22.50	23 18.028	+ 4 49.60	1.20	-19.58	.84	-15.42	10.1	17.6	43.7	54.3	77
1984	1	31	.0	2445730.5	23 20.690	+ 6 26.78	23 22.393	+ 4 43.03	1.19	-19.63	.83	-14.91	9.9	17.6	43.5	55.0	66
1984	2	1	.0	2445731.5	23 25.113	+ 6 31.33	23 26.818	+ 4 36.01	1.18	-19.68	.82	-14.37	9.7	17.6	43.4	55.7	55
1984	2	2	.0	2445732.5	23 29.595	+ 6 36.14	23 31.302	+ 4 28.52	1.17	-19.71	.81	-13.81	9.5	17.6	43.3	56.4	44
1984	2	3	.0	2445733.5	23 34.136	+ 6 41.20	23 35.845	+ 4 20.52	1.16	-19.73	.80	-13.23	9.4	17.6	43.2	57.1	34
1984	2	4	.0	2445734.5	23 38.735	+ 6 46.51	23 40.446	+ 4 11.99	1.14	-19.74	.80	-12.62	9.2	17.5	43.1	57.8	23
1984	2	5	.0	2445735.5	23 43.393	+ 6 52.07	23 45.105	+ 4 2.92	1.13	-19.74	.79	-11.98	9.0	17.5	43.1	58.5	14
1984	2	6	.0	2445736.5	23 48.109	+ 6 57.87	23 49.822	+ 3 53.26	1.12	-19.71	.78	-11.33	8.9	17.5	43.0	59.3	6
1984	2	7	.0	2445737.5	23 52.881	+ 7 3.90	23 54.596	+ 3 43.00	1.11	-19.68	.78	-10.65	8.7	17.5	43.0	60.0	13
1984	2	8	.0	2445738.5	23 57.711	+ 7 10.16	23 59.426	+ 3 32.11	1.10	-19.62	.77	-9.94	8.6	17.5	43.0	60.7	23
1984	2	9	.0	2445739.5	0 2.596	+ 7 16.64	0 4.313	+ 3 20.57	1.09	-19.55	.77	-9.22	8.4	17.4	43.0	61.5	33
1984	2	10	.0	2445740.5	0 7.537	+ 7 23.34	0 9.254	+ 3 8.35	1.08	-19.46	.76	-8.47	8.3	17.4	43.0	62.3	44
1984	2	11	.0	2445741.5	0 12.531	+ 7 30.25	0 14.250	+ 2 55.46	1.06	-19.36	.76	-7.70	8.2	17.4	43.0	63.0	56
1984	2	12	.0	2445742.5	0 17.580	+ 7 37.36	0 19.299	+ 2 41.85	1.05	-19.23	.75	-6.91	8.1	17.4	43.0	63.8	68
1984	2	13	.0	2445743.5	0 22.681	+ 7 44.66	0 24.401	+ 2 27.52	1.04	-19.08	.75	-6.11	8.0	17.4	43.1	64.5	81
1984	2	14	.0	2445744.5	0 27.833	+ 7 52.14	0 29.554	+ 2 12.45	1.03	-18.92	.74	-5.29	7.9	17.4	43.2	65.3	94
1984	2	15	.0	2445745.5	0 33.036	+ 7 59.78	0 34.757	+ 1 56.64	1.02	-18.73	.74	-4.45	7.8	17.4	43.3	66.0	107
1984	2	16	.0	2445746.5	0 38.288	+ 8 7.57	0 40.010	+ 1 40.06	1.01	-18.52	.74	-3.60	7.7	17.4	43.4	66.7	121
1984	2	17	.0	2445747.5	0 43.589	+ 8 15.49	0 45.311	+ 1 22.73	1.00	-18.30	.74	-2.75	7.7	17.4	43.5	67.4	135
1984	2	18	.0	2445748.5	0 48.938	+ 8 23.53	0 50.659	+ 1 4.64	.99	-18.05	.74	-1.88	7.6	17.4	43.7	68.1	149
1984	2	19	.0	2445749.5	0 54.334	+ 8 31.68	0 56.054	+ 0 45.78	.98	-17.78	.73	-1.01	7.6	17.3	43.9	68.8	164

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EPHEMERIS (WITH PERTURBATIONS) FOR P/CROMMELIN

YR	MN	DY	HR	J.D.	R.A. 1950.0	DEC.		R.A. APPN	DEC.	DELTA	DELDOT	R	RDOT	TMAG	NMAG	THETA	BETA	MOON
1984	2	20	.0	2445750.5	0 59.775	+ 0	15.37	1 1.495	+ 0 26.18	.97	-17.48	.73	-.14	7.6	17.3	44.1	69.4	177
1984	2	21	.0	2445751.5	1 5.262	- 0	4.90	1 6.981	+ 0 5.83	.96	-17.17	.73	.73	7.5	17.3	44.3	70.1	168
1984	2	22	.0	2445752.5	1 10.793	- 0	25.90	1 12.510	- 0 15.25	.95	-16.84	.74	1.60	7.5	17.3	44.5	70.7	155
1984	2	23	.0	2445753.5	1 16.367	- 0	47.60	1 18.083	- 0 37.04	.94	-16.49	.74	2.47	7.5	17.3	44.8	71.2	142
1984	2	24	.0	2445754.5	1 21.984	- 1	9.99	1 23.699	- 0 59.52	.93	-16.11	.74	3.33	7.5	17.3	45.1	71.8	130
1984	2	25	.0	2445755.5	1 27.644	- 1	33.04	1 29.357	- 1 22.67	.92	-15.72	.74	4.18	7.6	17.3	45.4	72.3	119
1984	2	26	.0	2445756.5	1 33.345	- 1	56.72	1 35.056	- 1 46.46	.91	-15.31	.74	5.02	7.6	17.3	45.8	72.7	107
1984	2	27	.0	2445757.5	1 39.087	- 2	21.00	1 40.796	- 2 10.87	.90	-14.88	.75	5.84	7.6	17.3	46.2	73.1	96
1984	2	28	.0	2445758.5	1 44.871	- 2	45.86	1 46.576	- 2 35.85	.89	-14.44	.75	6.65	7.7	17.3	46.5	73.5	86
1984	2	29	.0	2445759.5	1 50.694	- 3	11.25	1 52.396	- 3 1.37	.89	-13.97	.75	7.44	7.8	17.3	47.0	73.9	75
1984	3	1	.0	2445760.5	1 56.557	- 3	37.14	1 58.256	- 3 27.39	.88	-13.49	.76	8.22	7.9	17.3	47.4	74.2	65
1984	3	2	.0	2445761.5	2 2.460	- 4	3.48	2 4.155	- 3 53.88	.87	-13.00	.76	8.97	7.9	17.3	47.9	74.4	54
1984	3	3	.0	2445762.5	2 8.402	- 4	30.23	2 10.093	- 4 20.79	.86	-12.49	.77	9.71	8.0	17.3	48.4	74.6	44
1984	3	4	.0	2445763.5	2 14.383	- 4	57.34	2 16.070	- 4 48.06	.86	-11.96	.77	10.42	8.1	17.3	48.9	74.8	35
1984	3	5	.0	2445764.5	2 20.403	- 5	24.78	2 22.085	- 5 15.66	.85	-11.42	.78	11.11	8.2	17.4	49.4	74.9	26
1984	3	6	.0	2445765.5	2 26.461	- 5	52.47	2 28.138	- 5 43.54	.84	-10.87	.79	11.77	8.3	17.4	50.0	74.9	19
1984	3	7	.0	2445766.5	2 32.557	- 6	20.38	2 34.228	- 6 11.63	.84	-10.31	.79	12.41	8.5	17.4	50.5	74.9	17
1984	3	8	.0	2445767.5	2 38.690	- 6	48.45	2 40.356	- 6 39.90	.83	-9.73	.80	13.03	8.6	17.4	51.2	74.9	21
1984	3	9	.0	2445768.5	2 44.860	- 7	16.63	2 46.520	- 7 8.27	.83	-9.14	.81	13.62	8.7	17.4	51.9	74.8	28
1984	3	10	.0	2445769.5	2 51.066	- 7	44.86	2 52.720	- 7 36.71	.82	-8.54	.82	14.19	8.9	17.4	52.5	74.7	38
1984	3	11	.0	2445770.5	2 57.308	- 8	13.09	2 58.956	- 8 5.15	.82	-7.94	.83	14.73	9.0	17.4	53.2	74.5	48
1984	3	12	.0	2445771.5	3 3.583	- 8	41.25	3 5.225	- 8 33.55	.81	-7.32	.83	15.25	9.2	17.4	53.9	74.3	60
1984	3	13	.0	2445772.5	3 9.892	- 9	9.32	3 11.528	- 9 1.83	.81	-6.69	.84	15.75	9.3	17.4	54.7	74.0	71
1984	3	14	.0	2445773.5	3 16.234	- 9	37.21	3 17.862	- 9 29.95	.80	-6.06	.85	16.22	9.5	17.4	55.4	73.7	83
1984	3	15	.0	2445774.5	3 22.605	-10	4.86	3 24.227	- 9 57.85	.80	-5.41	.86	16.67	9.7	17.4	56.2	73.4	95
1984	3	16	.0	2445775.5	3 29.006	-10	32.24	3 30.621	-10 25.48	.80	-4.76	.87	17.10	9.8	17.4	57.0	73.0	107
1984	3	17	.0	2445776.5	3 35.434	-10	59.28	3 37.042	-10 52.77	.79	-4.11	.88	17.50	10.0	17.4	57.9	72.6	119
1984	3	18	.0	2445777.5	3 41.887	-11	25.93	3 43.488	-11 19.68	.79	-3.45	.89	17.89	10.2	17.4	58.6	72.2	130
1984	3	19	.0	2445778.5	3 48.363	-11	52.14	3 49.956	-11 46.16	.79	-2.78	.90	18.25	10.4	17.4	59.4	71.7	139
1984	3	20	.0	2445779.5	3 54.860	-12	17.86	3 56.446	-12 12.15	.79	-2.11	.91	18.59	10.5	17.4	60.2	71.2	146
1984	3	21	.0	2445780.5	4 1.375	-12	43.04	4 2.954	-12 37.61	.79	-1.43	.92	18.92	10.7	17.4	61.1	70.7	148
1984	3	22	.0	2445781.5	4 7.905	-13	7.63	4 9.477	-13 2.48	.79	-.75	.94	19.22	10.9	17.4	61.9	70.1	146
1984	3	23	.0	2445782.5	4 14.448	-13	31.59	4 16.013	-13 26.73	.79	-.07	.95	19.51	11.1	17.4	62.8	69.5	141
1984	3	24	.0	2445783.5	4 21.000	-13	54.88	4 22.558	-13 50.32	.79	.61	.96	19.78	11.3	17.5	63.6	68.9	134
1984	3	25	.0	2445784.5	4 27.558	-14	17.48	4 29.109	-14 13.21	.79	1.30	.97	20.04	11.5	17.5	64.5	68.3	127
1984	3	26	.0	2445785.5	4 34.117	-14	39.33	4 35.662	-14 35.37	.79	1.98	.98	20.28	11.7	17.5	65.4	67.6	119
1984	3	27	.0	2445786.5	4 40.676	-15	.42	4 42.214	-14 56.76	.79	2.66	.99	20.51	11.9	17.5	66.3	67.0	111
1984	3	28	.0	2445787.5	4 47.228	-15	20.73	4 48.761	-15 17.37	.79	3.35	1.00	20.72	12.1	17.5	67.1	66.3	103
1984	3	29	.0	2445788.5	4 53.772	-15	40.21	4 55.298	-15 37.17	.79	4.03	1.02	20.92	12.3	17.5	68.0	65.6	95
1984	3	30	.0	2445789.5	5 .302	-15	58.97	5 1.823	-15 56.14	.80	4.71	1.03	21.10	12.5	17.5	68.9	64.9	87
1984	3	31	.0	2445790.5	5 6.815	-16	16.68	5 8.330	-16 14.26	.80	5.39	1.04	21.28	12.6	17.5	69.7	64.2	79
1984	4	1	.0	2445791.5	5 13.306	-16	33.64	5 14.816	-16 31.54	.80	6.07	1.05	21.44	12.9	17.5	70.5	63.5	72
1984	4	2	.0	2445792.5	5 19.772	-16	49.74	5 21.277	-16 47.95	.81	6.74	1.07	21.59	.0	17.6	71.4	62.8	65
1984	4	3	.0	2445793.5	5 26.207	-17	4.97	5 27.708	-17 3.49	.81	7.41	1.08	21.73	.0	17.6	72.2	62.1	58
1984	4	4	.0	2445794.5	5 32.609	-17	19.34	5 34.105	-17 18.18	.81	8.08	1.09	21.86	.0	17.6	73.1	61.3	52
1984	4	5	.0	2445795.5	5 38.973	-17	32.85	5 40.465	-17 32.00	.82	8.74	1.10	21.98	.0	17.6	73.9	60.6	47
1984	4	6	.0	2445796.5	5 45.295	-17	45.51	5 46.784	-17 44.97	.82	9.39	1.12	22.09	.0	17.6	74.7	59.9	44
1984	4	7	.0	2445797.5	5 51.571	-17	57.32	5 53.057	-17 57.09	.83	10.04	1.13	22.20	.0	17.6	75.5	59.1	43
1984	4	8	.0	2445798.5	5 57.798	-18	8.30	5 59.281	-18 8.38	.84	10.69	1.14	22.29	.0	17.7	76.2	58.4	43
1984	4	9	.0	2445799.5	6 3.972	-18	18.47	6 5.453	-18 18.86	.84	11.33	1.15	22.38	.0	17.7	77.0	57.7	46

EPHEMERIS (WITH PERTURBATIONS) FOR P/CROMMELIN

YR	MN	DY	HR	J.D.	R.A. 1950.0	DEC.	R.A. APPN	DEC.	DELTA	DELDOT	R	RDOT	TMAG	NMAG	THETA	BETA	MOON
1984	4	10	.0	2445800.5	6 10.090	-18 27.84	6 11.570	-18 28.53	.85	11.96	1.17	22.46	.0	17.7	77.7	57.0	51
1984	4	11	.0	2445801.5	6 16.149	-18 36.44	6 17.627	-18 37.43	.86	12.58	1.18	22.54	.0	17.7	79.4	56.3	58
1984	4	12	.0	2445802.5	6 22.146	-18 44.28	6 23.623	-18 45.56	.86	13.20	1.19	22.61	.0	17.7	79.1	55.6	66
1984	4	13	.0	2445803.5	6 28.078	-18 51.39	6 29.554	-18 52.96	.87	13.81	1.21	22.67	.0	17.8	79.8	54.9	74
1984	4	14	.0	2445804.5	6 33.943	-18 57.79	6 35.419	-18 59.65	.88	14.42	1.22	22.72	.0	17.8	80.5	54.2	83
1984	4	15	.0	2445805.5	6 39.739	-19 3.51	6 41.214	-19 5.65	.89	15.01	1.23	22.78	.0	17.9	81.1	53.5	93
1984	4	16	.0	2445806.5	6 45.464	-19 8.57	6 46.939	-19 11.00	.90	15.60	1.25	22.82	.0	17.9	81.7	52.8	102
1984	4	17	.0	2445807.5	6 51.115	-19 13.01	6 52.591	-19 15.71	.91	16.18	1.26	22.86	.0	17.9	82.3	52.2	110
1984	4	18	.0	2445808.5	6 56.693	-19 16.84	6 58.170	-19 19.81	.92	16.76	1.27	22.90	.0	17.9	82.9	51.5	118
1984	4	19	.0	2445809.5	7 2.196	-19 20.11	7 3.673	-19 23.34	.93	17.32	1.29	22.93	.0	17.9	83.4	50.9	125

EXPLANATION OF SYMBOLS

J.D.= JULIAN DATE
R.A. 1950.0 DEC. = GEOCENTRIC RIGHT ASCENSION AND DECLINATION REFERRED TO THE MEAN EQUATOR AND EQUINOX OF 1950.0 - LIGHT TIME CORRECTIONS HAVE BEEN APPLIED
R.A. APPN DEC. = APPARENT GEOCENTRIC RIGHT ASCENSION AND DECLINATION - LIGHT TIME, ANNUAL ABERRATION, NUTATION CORRECTIONS HAVE BEEN APPLIED AND R.A. AND DEC. HAVE BEEN PRECESSED TO THE EPHEMERIS DATE
DELTA= GEOCENTRIC DISTANCE OF OBJECT IN A.U.
DELDOT = GEOCENTRIC VELOCITY OF OBJECT IN KM/SEC
R= HELIOCENTRIC DISTANCE OF OBJECT IN A.U.
RDOT = HELIOCENTRIC VELOCITY OF OBJECT IN KM/SEC

TMAG= TOTAL MAGNITUDE = 12.5 + 5.00*DLOG10(DELTA) + 36.40*DLOG10(R)
NMAG= NUCLEAR MAGNITUDE = 16.0 + 5.00*DLOG10(DELTA) + 5.00*DLOG10(R) + .03*BETA
NOTE: IN CASES WHERE TMAG AND/OR NMAG ARE NOT COMPUTED, THE CORRESPONDING COLUMN(S) ARE FILLED WITH ZEROES (0.0).

THETA = SUN-EARTH-OBJECT ANGLE IN DEGREES
BETA = SUN-OBJECT-EARTH ANGLE IN DEGREES
MOON = COMET-EARTH-MOON ANGLE IN DEGREES

OUTPUT TIMES IN ABOVE EPHEMERIS ARE IN E.T.

THE FOLLOWING OSCULATING ORBITAL ELEMENTS ARE CONSISTENT WITH THE ABOVE EPHEMERIS

EPOCH	2445760.50000	1984	3	1.00000
PERIHELION PASSAGE	2445750.66255	1984	2	20.16255
PERIHELION DISTANCE IN AU	.7345337			
ECCENTRICITY	.9191770			
ARG. OF PERIHELION	195.85131			
LONG. OF ASCENDING NODE	250.19244			
INCLINATION	29.10305			

IN THE ABOVE ORBITAL ELEMENTS, THE ANGLES ARE IN DEGREES AND REFERRED TO THE ECLIPTIC AND EQUINOX OF 1950.0
THE EPOCH AND PERIHELION PASSAGE TIMES ARE IN EPHEMERIS TIME

ORBIT AND EPHEMERIS COMPUTATIONS BY

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Comet Crommelin is active only for a few weeks on either side of perihelion. The crude total magnitude estimates are based upon this comet's brightness behavior in 1956. This ephemeris is based upon an orbit that used 37 observations over the period Sept. 30, 1956 until Oct. 27, 1983. A similar ephemeris by Dr. B.G. Marsden appears on I.A.U. circular 3886.

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